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IMMEDIATE DENTAL IMPLANT PLACEMENT IN POST-EXTRACTION-INFECTED SITES DECONTAMINATED WITH Er,Cr:YSGG LASER: A RETROSPECTIVE COHORT STUDY

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CERTIFICAN QUE. D. **RICCARDO AIUTO**, ha realizado bajo nuestra dirección el presente trabajo titulado: **"IMMEDIATE DENTAL IMPLANT PLACEMENT IN POST-EXTRACTION-INFECTED SITES DECONTAMINATED WITH Er,Cr:YSGG LASER: A RETROSPECTIVE COHORT STUDY"**, y reúne, en nuestro criterio, los requisitos y méritos suficientes para optar, mediante el mismo, al grado de Doctor en Odontología por la Universidad de Valencia.

Fdo.: Miguel Peñarrocha Fdo.: María Peñarrocha Fdo.: Francesca Angiero

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“È sapiente solo chi sa di non sapere,
non chi s'illude di sapere e ignora così perfino la sua stessa ignoranza."
(Socrate)

Abbreviations

BIC Bone-to-implant contact

CBCT Cone Beam Computed Tomography

DOPC Determined osteogenic precursor cell

Er,Cr:YSGG Erbium, chromium-doped yttrium scandium gallium garnet

Er:YAG Erbium-doped yttrium aluminium garnet

FDA Food and Drug Administration

GBR Guided bone regeneration

GTR Guided tissue regeneration

IPL Implant periapical lesion

LASER Light Amplification by Stimulated Emission of Radiation

LLLT Low level laser therapy

MBL Marginal bone level/loss

NADPH Nicotinamide Adenine Dinucleotide Phosphate

Nd:YAG Neodymium-doped Yttrium Aluminum Garnet

Nd:YAP Neodymium-doped Yttrium Aluminum Perovskite

PTFE Polytetrafluoroethylene

RCT Randomized clinical trail

STROBE Strengthening the Reporting of Observational Studies in Epidemiology

INDEX

SPANISH ABSTRACT (RESUMEN)

1. SPANISH ABSTRACT (RESUMEN)

Antecedentes científicos y objetivos de estudio

La técnica quirúrgica para la colocación inmediata de un implante dental en un alvéolo post-extracción fue propuesta inicialmente en 1976 por Schulte y Heimke. La colocación de implantes dentales en alveolos post-extracción ofrece ventajas tales como un tiempo de tratamiento reducido y una mayor comodidad para el paciente; además esta técnica permite reducir la exposición quirúrgica del paciente y limitar la reabsorción fisiológica ósea posterior a la extracción del diente, conservando la estética. La justificación para la extracción de un diente comprometido a menudo está relacionada con la presencia de una lesión periapical, consecuencia de una infección activa. Esto se considera tradicionalmente una de las principales contraindicaciones para la inserción inmediata del implante, debido a la mayor posibilidad de que la infección se propague a los tejidos periimplantarios durante la colocación del implante o en el período de cicatrización.

De todos modos, los estudios en animales han demostrado que la presencia de infecciones periodontales o endodónticas activas no compromete la osteointegración de los implantes colocados inmediatos a la exodoncia; además, el contacto hueso-implante (BIC) no se ve comprometido. Tras los primeros estudios, in vitro o en animales, algunos autores han propuesto un protocolo de implantología post-extracción en sitios con infección también en humanos. En una revisión sistemática de la literatura, Corbella et al. encontró nuevos estudios en humanos que incluían tasas de supervivencia que oscilaban entre el 92% y el 100% para un total de 497 implantes colocados en sitios con infecciones endodónticas; el seguimiento varió de 3 a 117 meses después de la carga. Se han propuesto diferentes enfoques para la descontaminación del sitio post-extractivo antes de la inserción del implante. Las medidas para disminuir la carga bacteriana de los sitios con infección incluyen procedimientos mecánicos y químicos como limpieza meticulosa, desbridamiento alveolar,

la administración de antibióticos y enjuagues bucales posoperatorios con clorhexidina al 0,12%. Se ha propuesto el uso de láseres como complemento de los procedimientos de desinfección, debido a que la tecnología láser es capaz de eliminar las bacterias de manera más eficaz que los productos químicos.

El momento ideal para la colocación del implante después de la extracción dental se ha discutido ampliamente en la literatura, se han atribuido ventajas y desventajas a los diferentes protocolos, aunque existe un interés creciente por acortar el tiempo total de tratamiento y minimizar el número de intervenciones quirúrgicas. Hämmerle et al. en el 2004 propusieron una clasificación para los tiempos de colocación de implantes, según la cual se identifica el implante tipo 1 como el que se coloca inmediatamente tras la extracción del diente, es decir en el mismo acto quirúrgico; el tipo 2 se coloca 4-8 semanas después de la exodoncia, y este tiempo suele corresponder a la maduración de los tejidos blandos; el tipo 3 se pone 12-16 semanas tras la extracción, cuando radiográficamente se puede ver el progreso de maduración del hueso en el sitio post-extracción; el implante tipo 4 se sitúa en un sitio post-extracción ya maduro, es decir por lo menos 16 semanas después de la exodoncia.

El implante de tipo 1 reduce el tiempo de tratamiento, utiliza todo el hueso existente disponible en la cresta alveolar y puede evitar la necesidad de levantar un colgajo. Por otro lado, el riesgo de infección (alvéolos infectados) es mayor. En ocasiones, una posible discrepancia entre la superficie del implante y la pared alveolar determina la necesidad de utilizar técnicas de aumento óseo. En situaciones donde sea necesario el avance de un colgajo para cubrir el implante y el posible material de injerto óseo, para conseguir una curación por segunda intención, supone un mayor riesgo de resultados estéticos. En realidad, todos estos inconvenientes también se pueden encontrar con otros protocolos de implantes no inmediatos.

El hecho de colocar un implante en un sitio infectado sugiere un mayor riesgo de infección; sin embargo, en los últimos años, la evidencia científica ha dado varias pruebas, de cómo este riesgo es comparable al de los implantes tipo 2, 3 o 4. Existen evidencias de cómo los procedimientos de desbridamiento mecánico y químico del sitio de post-extracción permiten reducir la presencia de bacterias. La imposibilidad de verificar la eliminación completa del biofilm bacteriano del sitio post-extracción junto con la eficacia probada del láser en tejidos duros y blandos ha llevado a algunos autores a proponer el uso del láser para la descontaminación de los alvéolos antes de la colocación del implante. Sin embargo, este método aún no se ha estudiado con ensayos clínicos controlados.

El objetivo de este estudio clínico controlado en una muestra de pacientes, realizado con al menos un año de seguimiento después del tratamiento, fue comparar el uso de implantes inmediatos en lugares infectados (tipo 1) descontaminados con láser Er,Cr:YSGG (test) versus implantes convencionales en sitios edéntulos cicatrizados (tipo 4).

Los objetivos específicos de la presente tesis fueron:

I. Comparar la diferencia en el nivel de hueso marginal (MBL) entre el momento de colocación de los implantes y en final del seguimiento.

II. Estudiar el posible fracaso de los implantes las complicaciones (como mucositis y periimplantitis), en el grupo estudio y en el control.

Material y métodos

Comité de ética

Este estudio recibió la aprobación del comité de ética de la Universidad de Valencia (n. 1606937298573) y se realizó en estricto cumplimiento de las declaraciones de STROBE (von Elm et al. 2008).

Diseño del estudio

Se realizó un estudio de cohortes retrospectivo. Se estudiaron una serie de pacientes tratados entre 2014 y 2019, con un seguimiento mínimo de 1 año, y hasta más de 4 años (no se realizó el cálculo del tamaño muestral, ya que, al ser un estudio retrospectivo, se incluyeron todos los pacientes posibles en el período de tiempo indicado). El estudio se llevó a cabo en el Istituto Stomatologico Italiano de Milán (Italia) y en la Unidad de Cirugía Oral de la Universidad de Valencia (España). Los pacientes tratados fueron informados y firmaron un consentimiento informado donde se explicaba que sus datos podrían usarse con un fin docente o ser usados para investigación.

Población del estudio

Grupo test (implantes tipo 1 en sitios infectados tratados con láser).

Criterios de inclusión:

- Pacientes ≥ 18 años.
- Sin condiciones médicas relevantes.
- Valores del índice de placa y de sangrado al sondaje ≤ 25 % para toda la boca.
- Seguimiento mínimo de 1 año después de la cirugía de implantes.
- Pacientes que recibieron terapia con implante inmediato en sitios infectados (por presencia de caries subgingival, enfermedad periodontal, lesión endodóncica o fractura) descontaminado con láser.

Criterios de exclusión:

- Pacientes con enfermedades sistémicas importantes.
- Antecedentes de radioterapia.
- Tratamiento actual con esteroides.
- Discapacidad neurológica o psiquiátrica.
- Estado inmunodeprimido.
- Pacientes con historia de tratamiento con bisfosfonatos.
- Mujeres embarazadas o en periodo de lactancia.

- Bruxismo severo.
- Pacientes con mala higiene oral y no colaboradores.
- Hábito de fumar (más de 15 cigarrillos al día), abuso de drogas o alcohol.

Grupo control (implantes tipo 4 en sitios no infectados).

Criterios de inclusión:

- Pacientes ≥ 18 años.
- Sin condiciones médicas relevantes.
- Valores del índice de placa y de sangrado al sondaje ≤ 25 % para toda la boca.
- Seguimiento mínimo de 1 año después de la cirugía de implantes.
- Pacientes que recibieron terapia con implante tipo 4 por edentulismo.

Criterios de exclusión:

- Pacientes con enfermedades sistémicas importantes.
- Antecedentes de radioterapia.
- Tratamiento actual con esteroides.
- Discapacidad neurológica o psiquiátrica.
- Estado inmunodeprimido.
- Pacientes con historia de tratamiento con bisfosfonatos.
- Mujeres embarazadas o en periodo de lactancia.
- Bruxismo severo.
- Pacientes con mala higiene oral y no colaboradores.
- Hábito de fumar (más de 15 cigarrillos por día), abuso de drogas o alcohol.

La primera fase del estudio incluyó la selección de las historias clínicas de los pacientes incluidos en el estudio, para completar el protocolo redactado, y la selección de las radiografías (radiografía periapical intraoral tomada con el anillo de posicionamiento y la técnica paralela). Los pacientes del

grupo estudio recibieron terapia con implantes dentales inmediatos colocados en sitios infectados, descontaminados con láser, y los del grupo control con implantes dentales con técnica tradicional.

Material

- Protocolo de recogida de los datos clínicos.
- Material para la cirugía de implantes: set quirúrgico de aislamiento de campo y aspirador quirúrgico, guantes estériles, gorro, gafas de protección y mascarilla, jeringa de anestesia, aguja desechable de anestesia, anestesia en carpules Optocain® (Mepivacaína 1: 100.000), espejos intraorales, suero fisiológico, gasas, despegadores y separadores de campo, láser Er, Cr: YSGG Waterlase iPlus® (Biolase, Foothill Ranch, USA), set quirúrgico de implantes Straumann® (Basel, Switzerland), contraángulo y motor quirúrgico, pinzas de disección, portaagujas, hilo de sutura, tijeras, sonda y periodontal.
- Biomateriales: en algunos casos se empleó una membrana absorbible (Collprotect®, Straumann®, Basel, Switzerland), Bio-Oss® (Woburn, MA, USA) y colágeno sintético (Septodont®, Mataró, España).
- Procedimiento protético: set protético de implantes Straumann®, resina Duralay®, silicona, cubeta de impresión.
- Material iconográfico: cámara digital NIKON® D7500 (Tokio, Japón), flash anular y espejos intraorales.
- Exploración radiológica: Heliodent Plus Dentsply Sirona® y posicionador de anillos para estandarización de proyecciones XPC de Rinn® (Dentsply®, Ilinois, Francia).
- Análisis radiológico: pantalla médica con una resolución de 1920 x 1080 y con aumento (7x) EIZO®.

Métodos

- Preparación prequirúrgica.

Se realizó una anamnesis y una exploración clínica meticulosas. Se realizó una radiografía intraoral o panorámica; se solicitó una tomografía computada de haz cónico cuando fue considerado necesario por el cirujano para evaluar el volumen óseo. Se obtuvieron modelos diagnósticos para establecer un correcto diagnóstico y efectuar la planificación quirúrgica y prostodóncica.

- Profilaxis antibiótica.

Se pautó tratamiento con amoxicilina, 1 gr. dos veces al día durante 6 días, que se inició la noche anterior a la cirugía. Esto se realizó tanto en el grupo test como ene grupo control.

- Cirugía de implantes.

Para la fase quirúrgica, todos los pacientes accedieron a un plan de tratamiento que incluyó la extracción de un diente comprometido, la descontaminación del sitio con láser Er, Cr: YSGG y la colocación de un implante en la misma sesión clínica, con el fin de reemplazar el diente faltante (grupo test).

Los dientes comprometidos se extrajeron de la forma más atraumática posible para proteger los tejidos circundantes, con la ayuda del láser Er, Cr: YSGG 2780 nm. El láser levantó el colgajo de espesor total con los siguientes ajustes: configuración para el modo de tejido blando, que incluía punta MC-3, longitud 9 mm, aire 20% y agua 80%. Para el tejido óseo, el modo de ajuste incluía la punta MZ-8, longitud 6 mm, aire 40% y agua 60%. Una vez que se completó la extracción, comenzó la fase de descontaminación del sitio infectado. El sitio se desbridó y descontaminó después de la extracción utilizando el mismo dispositivo láser pero con otra configuración: 2,0 W, 20% de aire y 80% de agua, mientras se montaba una punta MZ-6 de 9 mm de longitud. El tiempo de desbridamiento dependió de la cantidad de tejido patológico y del volumen óseo, la descontaminación duró de 60 a 90 segundos por alveolo, asegurando que no había contacto físico entre la punta del láser y los tejidos. El dispositivo Waterlase iPlus® (Biolase) se utilizó para todos los procedimientos con láser.

Las siguientes fases de la intervención consistieron en la colocación de los implantes (Straumann®). Los implantes se colocaron con un torque mínimo de 35 N y 1 mm por debajo del pico óseo más apical. A menudo, también fue necesario colocar biomateriales para el defecto residual causado por la infección, como en este caso de ejemplo: se utilizó una membrana absorbible (Collprotect®) y Bio-Oss® para mejorar la cicatrización del tejido. En algunos casos también se utilizó colágeno sintético (Septodont®). Se colocaron suturas (PTFE 3/0 Gore®) con especial cuidado para obtener un buen reposicionamiento del colgajo. Posteriormente, se prescribió gel de gluconato de clorhexidina al 0,2% dos veces al día durante 15-20 días y se dieron instrucciones postoperatorias al paciente. Se programaron controles clínicos y radiográficos periódicos. Los pacientes del grupo de control habían seguido un protocolo de implante similar, pero la extracción del diente había tenido lugar al menos 4 meses antes y no se había realizado una descontaminación láser del sitio.

- Fase protética.

Los implantes se cargaron inmediatamente o después de 3 meses. En este caso los implantes no se cargaron de forma inmediata sino que la fase provisional se gestionó con un puente Maryland. La posibilidad de carga inmediata se decidió en base a algunos parámetros clínicos como la estabilidad primaria del implante de acuerdo con el paciente.

- Análisis y medición de radiografías.

La segunda fase de este estudio incluyó la medición de radiografías digitales por un operador ciego (R.A.) con un software específico (Imagen J, Instituto Nacional de Salud, Bethesda, Rockville, MA, EE. UU.). Para las radiografías se habían utilizado los siguientes parámetros: 65-90 kV, 7,5-10 mA y 0,22-0,25 s. Antes de la medición, se calibró cada radiografía utilizando el diámetro y la longitud del implante como medidas de referencia para corregir cualquier distorsión.

Las radiografías se midieron en una pantalla médica con una resolución de 1920 x 1080 y con aumento (7x). El nivel de hueso marginal (MBL) se midió para la línea base y el seguimiento de acuerdo con Linkevicius et al., Calculando la distancia entre el cuello del implante y el primer contacto hueso-implante, y teniendo en cuenta tanto el aspecto mesial como el distal de cada implante. Para el análisis radiográfico se llevó a cabo un acuerdo intra-evaluador. Se midió una muestra independiente a priori de 20 superficies de implantes medidas dos veces, con 2 semanas de diferencia. El coeficiente de correlación intraclase bidireccional para el análisis de concordancia intra-evaluador radiográfico fue 0,97 (IC del 95% de 0,95 a 0,99).

- Análisis estadístico.

Como estadística descriptiva se utilizaron las desviaciones medias y estándar de las variables cuantitativas y la frecuencia y porcentajes de las variables cualitativas. Sin embargo, la unidad de análisis fue el implante, teniendo en cuenta el hecho de que a menudo se utilizaban varios implantes para cada paciente. Se utilizó un modelo estadístico mixto para la diferencia de la variable de resultado en MBL utilizando al paciente como un efecto aleatorio. La covariable fue el MBL al inicio del estudio y el grupo (implante tipo test o control) fue la variable explicativa (efecto fijo).

Para comparar las diferencias al principio del estudio entre los dos grupos (implantes test versus implantes control) se utilizaron modelos de efectos mixtos para las variables cuantitativas, edad, longitud del implante, diámetro del implante, MBL al inicio del estudio. También se utilizó un modelo de efectos mixtos para comparar la duración del seguimiento entre los dos grupos. El paciente fue el efecto aleatorio (efecto aleatorio) y el grupo (tipo test o control) fue la variable explicativa (efecto fijo). Para comparar las diferencias basales entre los dos grupos (implantes tipo test vs. implantes tipo control), se utilizaron modelos multinivel para las variables cualitativas: sexo, humo, arcada (superior o inferior), área (frontales - incisivos o caninos - vs. posteriores - premolar o molar -), motivos de extracción (fractura vs. otros), presencia de absceso o fístula, presencia de lesión, implantes con

cuello estrecho, carga inmediata, uso de membrana, uso de colágeno, uso de hueso sintético. Los modelos fueron a dos niveles (paciente e implante) y el grupo (implante de prueba o control) fue la variable explicativa. El umbral de significación se fijó en 0,05. Las estadísticas se realizaron con el software JMP v. 13.0 y con MLwin v. 3.05.

Resultados

En este estudio clínico controlado se trataron 98 pacientes con una edad promedia de 58.0 ± 14.6 años (de 21 a 88 años), 52 mujeres (53%) y 46 hombres (47%); hubo un total de 22 fumadores en la muestra (22%); el análisis retrospectivo permitió analizar un total de 149 implantes colocados, 90 (60%) fueron tipo test y 59 (40%) tipo control. Se colocaron implantes tipo test en 53 pacientes (1 implante en 35 pacientes, 2 implantes en 10 pacientes, 3 implantes en 4 pacientes, 4 implantes en 3 pacientes y 5 implantes en 1 paciente). Se colocaron implantes tipo control en 39 pacientes (1 implante en 29 pacientes, 2 implantes en 7 pacientes, 3 implantes en 3 pacientes). Se colocaron implantes tipo test y control en 6 pacientes (1 implante tipo test y 1 implante tipo control en 5 pacientes, 1 implante tipo test y 2 implantes tipo control en 1 paciente).

Las variables relacionadas con la cirugía incluyen diferentes características: arcada superior o inferior, zona (anterior o posterior), motivo de la extracción (fractura, absceso o fístula), presencia y dimensión de la lesión apical, uso de implante con cuello estrecho, longitud y diámetro del implante, uso de carga inmediata, uso de membrana, colágeno o hueso sintético, medición del MBL posoperatorio. En el grupo test hubo lesiones con mayor frecuencia, la longitud del implante fue superior de aproximadamente 1 mm. La membrana y el hueso sintético se utilizaron con mayor frecuencia en el grupo test en comparación al grupo control. En particular, los motivos de la extracción en el grupo test fueron: caries (subgingivales, en dientes irrecuperables) en 32 dientes (36%), lesiones endodónticas en 10 dientes (11%), fracturas en 43 dientes (48%) y problemas

periodontales (dientes con enfermedad periodontal y movilidad grado II o III) en 5 dientes (6%). En el grupo control los motivos de la exodoncia fueron: caries (subgingivales, en dientes irrecuperables) en 20 dientes (34%), lesiones endodónticas en solo 1 caso (2%), fracturas en 31 dientes (52%) y problemas periodontales (dientes con enfermedad periodontal y movilidad grado II o III) en 7 dientes (12%).

Todos los implantes colocados fueron de la casa comercial Straumann®, sin embargo, estos tenían características diferentes para adaptarse a todas las situaciones clínicas. En el grupo test, se utilizaron los siguientes tipos de implantes: 33 implantes TE RN Loxim SLA Roxolid (37%), 37 implantes S RN Loxim SLA Roxolid (41%), 4 implantes SP RN Loxim SLA TiZr (4%), 3 implantes SP NNC SLAactive TiZr (3%), 4 implantes S RN SLAactive Roxolid (4%), 9 implantes SP NNC Loxim SLA Roxolid (10%). En cambio, en el grupo control, los implantes fueron: 6 TE RN Loxim SLA Roxolid (10%), 39 implantes S RN Loxim SLA Roxolid (66%), 4 implantes SP RN Loxim SLA TiZr (7%), 0 implantes SP NNC SLAactive TiZr (0%), 0 implantes S RN SLAactive Roxolid (0%), 10 implantes SP NNC Loxim SLA Roxolid (17%).

El seguimiento promedio fue de 1,7 ± 0,6 años en el grupo test y 1,5 ± 0,5 años en el grupo control, con una diferencia no estadísticamente significativa (P = 0,082; modelo mixto). Solo hubo un fracaso en el grupo test (1%) y ningún fracaso en el grupo control. Se registró una complicación (mucositis) en el grupo control (2%) y ninguna aparte del fracaso en el grupo test. La diferencia en MBL entre los dos grupos fue a favor del grupo test, que incluso ganó 0,1 mm en comparación con la línea de base, mientras que el grupo de control perdió 0,1 mm en MBL. Sin embargo, la diferencia entre los dos grupos fue de solo 0,2 mm, y por lo tanto no es estadísticamente significativa (aunque si era cerca del límite P = 0,058).

Discusión

Objetivo del estudio

El objetivo principal fue comparar los implantes post-extracción en sitios con infección y los implantes colocados con la técnica tradicional; estos últimos, se posicionaron al menos tres meses después de la exodoncia y en alvéolos sin signos de infecciones residuales. Los resultados indicaron que no había diferencia del MBL entre los dos grupos analizados. De hecho, el MBL al inicio del estudio fue de 2,4 en ambos grupos ($p = 0,912$). Dado que no siempre es fácil identificar la presencia de una infección activa, cuando es necesario extraer un diente comprometido, se eligieron los implantes tipo 4 para el grupo control, los cuales se colocaron en áreas edéntulas con buena cicatrización del alveolo post-extracción. Por lo tanto, en esta situación hubo menos riesgo de que siguieran permaneciendo colonias de bacterias en una zona desdentada.

Resumen de los principales hallazgos

Leyendo los resultados, los dos grupos parecen suficientemente homogéneos en términos de edad y sexo de los pacientes y áreas tratadas. Las opciones quirúrgicas, como la longitud del implante o el uso de biomateriales, variaron según la situación clínica. Específicamente, en el grupo test, los implantes eran más largos: la longitud del implante era mayor de aproximadamente 1 mm en el grupo test, mientras que el diámetro era muy similar en los dos grupos. Además, a excepción del colágeno, que tuvo una tasa de utilización similar en los dos grupos, la membrana y el hueso autólogo se utilizaron con mayor frecuencia en el grupo test. Esto se debe a que en el grupo test la presencia de lesiones fue más alta y, por lo tanto, los defectos óseos también se trataron con mayor frecuencia; la literatura científica también muestra que el manejo del alveolo después de la extracción a menudo requiere el uso de biomateriales para la regeneración del tejido periimplantario. Una revisión sistemática reciente muestra que el injerto óseo, llevado a cabo simultáneamente a la colocación inmediata del implante, da como resultado la preservación de las dimensiones de los tejidos duros y blandos; además, la aplicación de técnicas de regeneración ósea guiada ayuda a la preservación de

los tejidos blandos y previene la reabsorción del hueso cortical vestibular del implante inmediatamente colocado, a pesar del tipo de membrana utilizada.

Una radiografía antes de colocar el implante en el sitio post-extracción después de 12 o 16 semanas de cicatrización permitió comprobar la presencia de lesiones osteolíticas. Sin embargo, estudios recientes muestran que incluso después de un período adecuado de curación, pueden permanecer bacterias en el hueso que pueden afectar a la supervivencia del implante. La introducción del láser en la implantología, por lo tanto, no solo hace que la técnica inmediata de colocación del dispositivo sea más segura: la descontaminación láser también podría ser útil en la extracción de dientes con lesiones para hacer las futuras rehabilitaciones con implantes más predecibles, incluso si se realizan de manera diferida.

Este estudio analizó 149 implantes en total, con mediciones de MBL mesial y distal al inicio y al seguimiento, y es por el momento el único estudio controlado en la literatura sobre la colocación de implantes en sitios infectados descontaminados con Er,Cr:YSGG 2780 láser, según el conocimiento de los autores. Además, el presente estudio incluye muchos casos llevados a cabo en los sectores posteriores, a diferencia de los muchos estudios de implantología inmediata (tipo 1) que suelen realizarse exclusivamente en áreas estéticas, donde hay menos estrés de carga masticatoria. En una revisión sistemática y un metaanálisis recientes, Lee et al. mostró la misma conclusión alentadora al analizar cinco estudios prospectivos, que no involucraban el uso de láser, sino una técnica de desbridamiento más convencional; los mismos autores informaron sobre la ausencia de estudios clínicos controlados sobre el tema en la literatura científica actual. En un estudio de Kakar et al., publicado recientemente, los autores siguieron un protocolo clínico similar al presente estudio, que incluía un desbridamiento con láser Er, Cr: YSGG 2780 nm, para tratar una serie de casos sin grupo control. Sin embargo, a pesar de que no iban a medir el MBL, el dato interesante es la supervivencia

de los implantes que supera el 95% y, por tanto, está en línea con la tasa de supervivencia que se espera con las técnicas de implantología convencionales.

Discusión con literatura previa

Teniendo en cuenta los resultados de una Conferencia de consenso del 2017 sobre la clasificación de enfermedades y afecciones periodontales y periimplantarias, para evaluar el éxito de la terapia con implantes, es importante calcular el MBL, ya que hasta los 2 mm puede considerarse como remodelado fisiológico óseo. Otro factor que hay que considerar es la inspección visual, que demuestre la ausencia de signos de inflamación periimplantaria, con un color rosa del tejido blando y sin hinchazón; además hay que averiguar la falta de sangrado profuso (línea o gota) al sondaje. Las profundidades del sondaje pueden diferir según el biotipo del tejido blando y la ubicación del implante. Sin embargo, un aumento de la profundidad de sondaje con el tiempo sin dudas entra en conflicto con la salud periimplantaria.

Los datos obtenidos sobre el MBL en esta investigación no solo están en línea y son más bajos en comparación con el grupo control, sino que también son comparables a los de los otros estudios. Entre estos, Berberi et al. describió el MBL en técnicas de carga inmediata y diferida de implantes post-extracción; también la carga inmediata parece garantizar resultados clínicos prometedores como demuestran varios casos en el presente estudio. De hecho, en el trabajo de Barbieri y cols., también se observó un MBL significativamente menor asociado con implantes cargados inmediatamente e insertados en alveolos post-extracción en comparación con la técnica de carga diferida. Por lo tanto, se rechazó la hipótesis sugerida de que se observaría un mayor MBL en los implantes cargados inmediatamente. La reformación rápida y reproducible de la mucosa periimplantaria y la salud gingival se pueden atribuir a un MBL mínimo, con aplicación inmediata de las prótesis provisionales y, por lo tanto, la ausencia de manipulación del pilar durante el período de cicatrización.

En cuanto a las fases de carga y prótesis, este estudio comparó un porcentaje similar de carga inmediata entre el grupo test y el grupo de control. Esto hace que el análisis sea más completo y agregue una serie de variables que, sin embargo, no influyeron en los resultados clínicos y estadísticos. Otra motivación clínica, acerca de la mínima diferencia en el MBL de los dos grupos, puede derivar del hecho de que las técnicas regenerativas a menudo se aplicaban más a los implantes tipo 1, a causa de los defectos de hueso que se apreciaban tras la exodoncia.

Ventajas, limitaciones y recomendaciones para estudios futuros

Estudios anteriores que compararon radiografías panorámicas y periapicales indicaron que las periapicales eran el "Gold Standard" para medir el MBL alrededor de los implantes dentales. Un CBCT también sería útil, pero, debido a la dosis de rayos y la falta de justificación, no sería posible encontrar un número considerable de pacientes para el estudio. El examen radiográfico 3D se utilizó solo en algunos casos y se realizó muchas veces para otras necesidades clínicas. La necesidad de disponer de radiografías comparables ha implicado una escrupulosa selección de pacientes con el fin de aumentar la fiabilidad de los datos. Esto podría ser una limitación del presente estudio. En este contexto, otra limitación del presente estudio fue el número relativamente bajo de pérdidas de implantes; específicamente, debido a esto, un análisis de regresión logística de efectos aleatorios no fue significativo y, por lo tanto, los predictores potenciales registrados no podrían estar relacionados con la pérdida de implantes temprana ni tardía. Además, se trata de un estudio retrospectivo, lo que por lo tanto implica la presencia de algún sesgo, aunque con un protocolo quirúrgico ya publicado en estudios anteriores de los mismos autores. En el presente estudio, solo 10 casos tuvieron una lesión endodóntica franca; es deseable realizar estudios prospectivos solo sobre implantes colocados en sitios con lesiones endodónticas. Finalmente, otra limitación del estudio es que, en ambos grupos, se administró profilaxis antibiótica a los pacientes tratados. Esto se debe a que la evidencia científica más reciente sugiere el uso de antibióticos para prevenir infecciones sistémicas peligrosas para la salud del paciente (como la endocarditis bacteriana). Según los autores de una revisión reciente de la

literatura científica, el uso de profilaxis antibiótica puede disminuir los fracasos tempranos de los implantes, pero todavía hay evidencia insuficiente para recomendar con seguridad una dosis específica.

Conclusiones

De la presente tesis se pueden extraer las siguientes conclusiones:

I. El resultado de que no hay diferencia en MBL, que es incluso casi mejor en el grupo test, parece prometedor para incentivar la aplicación clínica del protocolo descrito para la colocación de implantes tipo 1 en sitios infectados.

II. La tasa de complicaciones o fracasos es comparable entre los dos grupos y, por lo tanto, se puede afirmar que no existe un mayor riesgo en el grupo test.

INTRODUCTION

2. INTRODUCTION

The surgical technique for the immediate placement of a dental implant in an extraction socket was initially proposed in 1976 by Schulte and Heimke [Schulte W et al. 1976]. Today the technique is widely used, and it is also called type 1 implant. Hämmerle et al. in 2004 proposed a classification for implant placement times, according to which the type 1 implant is identified as the one that is placed immediately after tooth extraction, in the same surgical act; type 2 is placed 4-8 weeks after the extraction, and this time usually corresponds to the maturation of the soft tissues; type 3 is placed 12-16 weeks after extraction, when the progress of bone maturation in the post-extraction site can be seen radiographically; the type 4 implant is placed in an already mature post-extraction site, that is at least 16 weeks after extraction [Hammerle et al. 2004].

The placement of dental implants into fresh extraction sockets offers advantages such as a reduced treatment time and enhanced patient comfort [Koh et al. 2010]; besides this technique allows to reduce the patient's surgical exposure and limits the physiological bone resorption after tooth extraction preserving esthetic [Paolantonio et al. 2001]. The contextual immediate loading of such implants has also been proposed, and positive results are reported [Werbitt et al 1992]. Thanks to the foregoing advantages, in recent years the immediate insertion of an implant after tooth extraction has become a common treatment option.

The extraction of a compromised tooth is often linked to the presence of a periapical lesion, indicative of an active infection. This is traditionally considered one of the main contraindications to immediate implant insertion because of the increased possibility of the infection spreading to peri-implant tissues during the healing period. In fact, Schwartz-Arad et al. showed the indications for post-extraction implant, such as trauma, decay without purulence, endodontic failure, severe periodontal bone loss, residual root, and contraindications, such as presence of pus, lack of bone beyond the apex or close

relationship to the anatomical vital structures [Schwartz-Arad et al 1997]. However, animal studies have shown that the presence of active periodontal or endodontic infections does not compromise the osseointegration of implants placed at once; additionally, bone-to-implant contact (BIC) is not compromised [Chang et al. 2009, Marcaccini et al. 2003, Novaes et al 2003, Novaes et al. 2004, Papalexiou et al. 2004]. After the first in vitro or animal studies, that have several limitations, such as the small sample sizes, absence of occlusal loading and locations of control and experimental teeth, some authors have begun to propose a post-extraction implantology protocol in infected sites also in humans. That's why an ever-increasing number of authors have described the possibility of implant placement in post-extraction-infected sites, although dependent on whether the correct indicators are present and if a strict decontamination protocol is adhered to. In a systematic review of the literature, Corbella et al. found nine human studies reporting survival rates ranging between 92% and 100% for a total of 497 implants placed in sites with endodontic infections; the follow-up varied from 3 to 117 months after loading [Corbella et al. 2013]. More recently, Lee's review analyzed five clinical trials affirming that implants can be placed in infected extraction sockets after thorough socket debridement; nevertheless, the same authors reported the absence of RCTs on the topic in the literature [Lee et al 2018].

Different approaches have been proposed for the decontamination of the post-extraction site prior to implant insertion. Measures to decrease the bacterial load of infected sites include mechanical and chemical procedures like meticulous cleaning, alveolar debridement, the administrations of antibiotics, and postoperative Chlorhexidine 0.12% mouth rinses [Crespi et al. 2010, Bell et al. 2011, Fugazzotto et al 2012]. Assuming these clinical procedures and socket decontamination techniques are employed, the presence of a periradicular, periapical, or endodontic infection, or carious lesions doesn't seem to affect implant survival rate [Jofre et al. 2012]. Marconcini et al. even proposed tooth extraction with extreme care to preserve the alveolar bony integrity and careful curettage of the sockets to remove the remaining granulation tissue without alveoli local disinfection but only with

antibiotic therapy [Marconcini et al. 2013]. However, it must be considered that the bacterial biofilm can escape the action of mechanical tools and chemical irrigants to cleaning the post-extraction socket. Furthermore, there is no possibility of measuring bacterial persistence in the infected site, such as is done with a caries detector in restorative dentistry, during surgery. For this reason, Kusek proposed the use of lasers as an adjunct to disinfection procedures, because laser technology is capable of eliminating bacteria more effectively than chemical products (1000 vs. 100 μm) [Kusek 2011].

RATIONALE AND STUDY AIMS

3. RATIONALE AND STUDY AIMS

3a. Rationale

The ideal timing of implant placement after dental extraction has been extensively discussed in the literature, and advantages and disadvantages have been attributed to the different protocols [Esposito et al. 1998; Chen et al. 2004; Fugazzotto 2005], although there is an increasing interest for shortening the overall treatment time and minimizing the number of surgical interventions. The implant type 1 results in shorter treatment time, utilizes all available existing bone in the ridge and may avoid the need for raising a flap. On the other hand, it's possible to have an increased risk of infection (infected alveoli) [Rosenquist & Grenthe 1996]; the presence of a discrepancy between the surface of the implant and the socket wall with a need to combine with bone augmentation techniques; the need to advance the flap to cover the fixtures in situations aiming for a healing by secondary intention [Rosenquist & Ahmed 2000]; an higher risk for compromised aesthetic outcomes [Kan et al. 2007; Chen & Buser 2009; Sanz et al. 2009].

In truth, all these drawbacks can also be found in other implant protocols. Certainly, the fact of placing an implant in an infected site may suggest an increased risk of infection, but scientific evidence is recently giving various proofs of how this risk is also comparable to that of implants type 2, 3 or 4. In fact, there is evidence of how the mechanical and chemical debriding procedures of the post extraction site allow to reduce the presence of bacteria [Marconcini et al. 2013].

The impossibility of verifying the complete removal of the bacterial biofilm from the post-extraction site together with the proven effectiveness of the laser on hard and soft tissues has prompted some authors to propose the use of the laser for the decontamination of the alveoli before implant placement [Kusek 2011]. However, this method has not yet been studied with a controlled clinical trial.

3b. Study aims

Main objective

The objective of this controlled study, conducted within at least one year of follow-up after treatment, was to compare the use of immediate post-extraction implants in infected sites decontaminated with Er,Cr:YSGG laser (test) versus conventional implants in edentulous sites (control) in a sample of treated patients.

Specific objectives

The specific objectives of the present thesis were:

I. Comparing the difference in marginal bone level (MBL) between the follow-up and baseline (implant placement).
II. Comparing the outcome variables included implant failure and complications (such as mucositis and peri-implantitis).

STUDY HYPOTHESES

4. STUDY HYPOTHESES

Comparing the use of immediate post-extraction implants in infected sites decontaminated with Er,Cr:YSGG laser (test) versus conventional implants in edentulous sites (control).

The following study hypotheses were formulated:

Null hypothesis I

H_0 The difference in marginal bone level (MBL) between the follow-up and baseline (implant placement) will be similar in both technique.

Null hypothesis II

H_0 The outcome variables included implant failure and complications will be similar in both gruops.

LITERATURE REVIEW

5. LITERATURE REVIEW

5a. Characteristics of the alveolar bone and healing of the post-extraction socket

The alveolar bone

The alveolar bone, together with the gum, the cementum, and the periodontal ligament, constitutes the periodontium, or rather the attachment apparatus of the teeth, with the function of distributing and absorbing masticatory forces [Wegner 1964]. The tooth is anchored to the mandible through the collated bone, which is invested by the fibers of the periodontal ligament. The volume and shape of the alveolar process is determined by the shape of the teeth, their axis of eruption and any inclinations [Schroeder 1986]. As a result of the removal of the teeth, the alveolar process undergoes atrophy; at that point, the collated bone obviously loses its function and disappears [Arau & Lindhe 2005]. Rarely, usually when comorbidities are present, serious diseases such as osteonecrosis can also occur (fig.1). The formation of alveolar bone is due to the action of osteoblasts: they produce osteoid, that is, an organic substance formed by collagen fibers and a matrix consisting mainly of glycoproteins and proteoglycans; this osteoid, rich in proteins that expose negative charges, undergoes calcification through the deposition of minerals, such as calcium and phosphate; the subsequent addition of hydroxide ions and bicarbonate gives rise to hydroxyapatite crystals, which represent bone in its mature form [Eger 1963].

During the maturation and calcification process, some osteoblasts named osteocytes are trapped in the matrix undergoing ossification; despite being trapped inside the calcific bone, they continue to communicate and receive nourishment with the external environment through intraosseous canaliculi. During life, the alveolar bone, being a metabolically active tissue, is continuously renewed, through neo-apposition and remodeling processes, in response to functional needs and in response to the

forces that develop inside the oral cavity, following the chewing, swallowing and bad habits. For this reason, over the years, the teeth undergo migration, and the alveolar bones change shape and size.

Bone resorption is due to osteoclasts: specialized giant cells that originate from blood monocytes and that lodge inside the so-called Howship lacunae, carved into the bone by themselves. They are mobile cells, able to migrate on the bone surface and to adhere to it; at this point with their membrane they delimit a small space close to the bone tissue, in which they will release lactic acid (which breaks down the mineral component) and lytic enzymes (capable of degrading bone proteins): in this way they produce osteolysis, i.e. the resorption of the bone matrix. The residual organic substances are then eliminated by osteoclastic phagocytosis: thus, bone resorption occurs [Bélanger 1969].

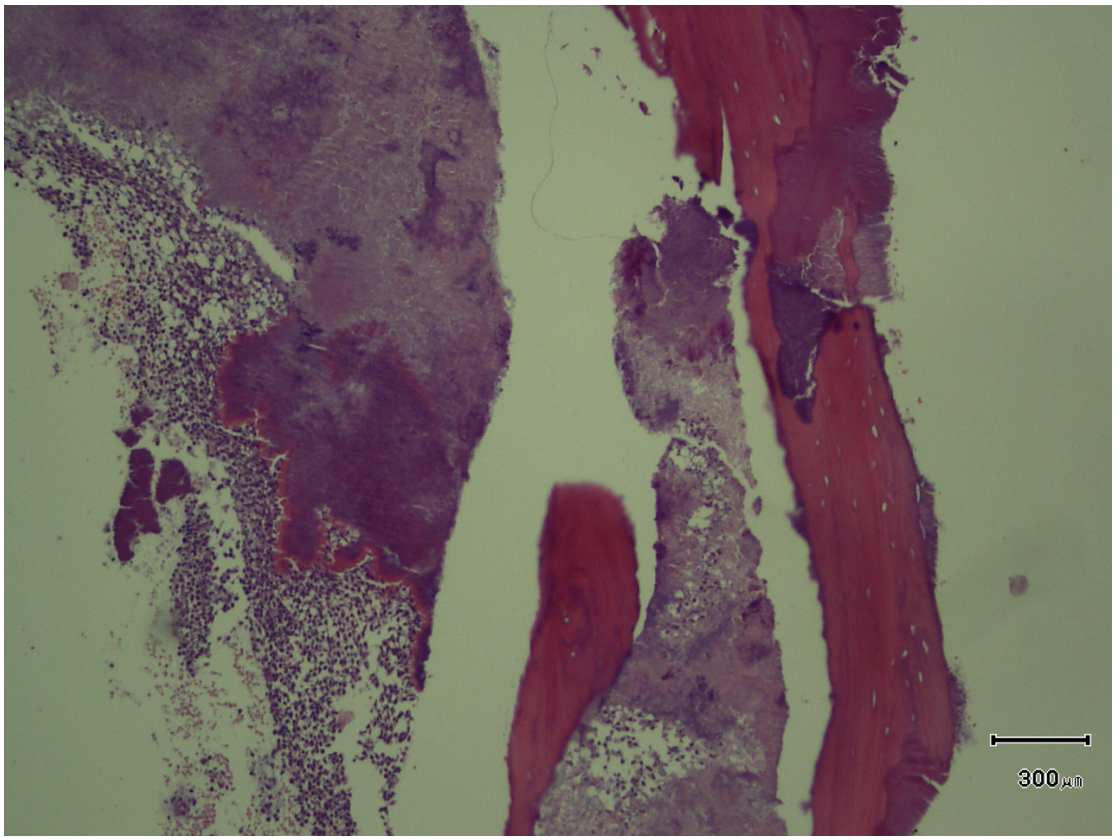


Figure 1.1. Osteonecrosis and osteomyelitis of the jaw. Courtesy of prof. Francesca Angiero.

The healing of post extraction socket

When, during life, a tooth is lost, following an extraction or a traumatic event, a healing process of the alveolus is established which leads to a deposition of bone tissue in the space previously occupied by the root of the dental element. Bone regeneration processes originate from osteogenic cells, ie progenitor cells of osteoblasts, present both in the stromal part of the medulla (near the blood vessels), and in the endosteum and periosteum that cover the bone surfaces. These are called DOPC cells "determined osteogenic precursor cell", due to their ability to form bone without the influence of any inductive agent. Bone is produced by osteoblasts, in fact they cover all bone surfaces that show active bone formation. These cells, however, are unable to migrate or move, so they are unable to proliferate within a bone defect; for this reason the healing of a bone defect depends exclusively on the presence of osteogenic precursor cells in the surrounding bone or surrounding tissues and on their ability to invade the defect and differentiate into osteoblasts [Urist 1965; Friedenstein et al. 1992].

After the extraction of a tooth, processes are triggered in the alveolus and lead to the regeneration of the alveolar bone:

1. At first the site is filled with blood, serum and saliva which, after a few minutes, will organize themselves into a clot. The formation of a stable clot is essential for the correct filling of the intraosseous defect: in fact, it will act as a “scaffold” on which osteogenic cells can migrate.

2. One day after extraction, we will find fibroblasts and fibrin in the most peripheral portion of the clot; the osteoblasts begin to cover the bone margins and the osteoclasts determine a minimum resorption of the edge of the alveolus, necessary to induce the osteoblasts to produce their bone matrix. Finally, lymphocytes and leukocytes appear.

3. Two days after the extraction, there is the formation of a real granulation tissue, characterized by the presence of blood vessels, fibroblasts and leukocytes. With a process of hemolysis, the inflammatory cells begin to dissolve the clot in its central part.

4. At one week the granulation tissue is predominant: there are fibroblasts, collagen fibers and blood vessels that are organized in a new vascular network (neoangiogenesis). Bone deposition begins in the most apical portion of the alveolus, with the formation of an osteoid. In this phase, the migration of the epithelial cells on the granulation tissue also begins: thus, the epithelial covering of the wound begins; due to this process, if a stable clot had not previously been created, there is a risk that the epithelial cells would fill a part of the bone defect, causing a loss in height of the alveolar process.

5. On about the 14th day, the marginal portion of the alveolus appears covered with immature connective tissue, rich in inflammatory cells and vessels and the appearance of osteoid tissue along the walls is observed.

6. After 4-6 weeks the alveolus fills with connective tissue and bone tissue; in the meantime, the epithelium completely closes the surface and progressively keratinizes. In the first month, mainly lamellar bone is formed which is accompanied by the resorption of the hard lamina of the alveolus.

7. After 2 months, the alveolus shows a bone neostructure, but its complete healing can take up to 4 months. Usually, the healed post-extraction socket never reaches the vertical height of the alveoli of the neighboring dental elements.

Most of the time the post-extraction socket heals without complications; but, even in uncomplicated healing, the alveolar defect that results from tooth removal will only be partially repaired. In fact, in

conjunction with the growth of bone inside the alveolus, there is also a resorption of the alveolar ridge. The greatest amount of bone loss occurs in the horizontal dimension, and this takes place mainly on the buccal side of the ridge. There is also a loss in the vertical dimension of the ridge, which, on the other hand, is more pronounced on the buccal side. This resorption process takes the form of a narrower and shorter ridge relocated in a more lingual/palatal position [Araújo & Lindhe 2005; Pinho et al. 2006]. The alveolar defect resulting from the loss of a tooth can also be complicated by previous bone loss due to periodontal disease, endodontic injury or traumatic episodes. Most of the alveolar bone loss occurs in the first 6 months, but the bone resorption activity continues throughout life, at a slower speed, eventually leading to the removal of a large amount of mandibular structure [Jahangiri et al. 1998].

A systematic review of the literature performed by Van der Weijden et al. studied the dimensional changes of the alveolar bone, analyzing 12 studies that had evaluation periods ranging from 3 to 12 months. The results of this systematic review show that on average about 2.57 mm of vertical filling can be expected in the post-extraction socket. On the other hand, we will observe a decrease in the height of the ridge, which, based on radiographic measurements, is approximately 1.59 mm; considering the clinical evaluations, however, this loss of vertical dimension consists of 1.67 mm on the buccal side and 2.03 mm on the lingual side [Van der Weijden et al. 2009]. These data do not support those reported by Araùjo & Lindhe: these authors concluded that, in their canine models, when the most coronal part of the buccal bone wall was composed solely of fasciculate bone (bone containing part of the periodontal ligament fibers), bone remodeling led to a much greater vertical reduction of the buccal crest than the lingual crest. On average, the difference between lingual and buccal ridge resorption was approximately 2 mm in their experiments with canine models [Araújo & Lindhe 2005].

However, according to the systematic review of the literature by Van der Weijden, the reduction in height should be 2.59 (± 1.85) on the buccal side and 2.03 (± 1.78) on the lingual side. Although the resorption is more pronounced on the buccal side, the difference (0.56 mm) is still not as important as reported by Araùjo & Lindhe.

A study conducted by Nevins et al. determined the fate of the thin buccal bone plate, following the extraction of the prominent roots of the maxillary anterior teeth [Nevins et al. 2006]. They evaluated the height of the ridge in sites where the horizontal dimension was at least 6 mm, using CT scans. With this very precise method they observed a reduction in height of 5.24 mm in these sites. The illustration provided in this study shows that this was mainly the result of the resorption of the vestibular cortex. These data correspond to those concerning the canine models of Araùjo & Lindhe. However, the clinically calculated bone losses in the systematic literature review performed by Van der Veijde et al. do not validate this finding. The most likely explanation is that, on average, the vestibular lamina in humans is as prone to resorption as the lingual part of the ridge. Both show a reduction of approximately 2 mm following the extraction. From this systematic review it can be concluded that during the post-extraction healing period, the clinical loss in the bucco-lingual dimension of the ridge (3.87 mm) is greater than the loss in height. Johnson reported that processes leading to bone reduction appear to be more pronounced in the early stage of wound healing, rather than during the subsequent period following tooth extraction. Most dimensional changes in the alveolar ridge - both vertical and horizontal - occur during the first 3 months of healing [Johnson 1969].

5b. Post-extractive dental implants

In the past, the protocol for the positioning of an implant to replace a dental element to be extracted involved a 2-stage intervention: in a first session the dental element was extracted and, after the management of the residual alveolus, the tissues were closed and the it gave the bone time to heal (about 3-6 months); in the second session the implant was actually inserted into the mature bone.
However, in the last 20 years, a better understanding of the therapeutic use of dental implants has led to radical changes in traditional guidelines for implant surgery: advancement in biomaterial technology, as well as the optimization of implant surface profiles and characteristics, have provided clinicians with improved protocols to supply more advanced treatment options. Today, in fact, in patients who have alveolar bone of a certain quantity and quality, such that it is able to guarantee primary stability, we can use the post-extraction implant protocol, i.e. an implant placed immediately after (or a few days after) the dental extraction, without having to wait for the complete healing of the bone tissue. Several clinical trials in humans have demonstrated high levels of success for implants placed in extraction sockets.

The first studies performed on animals have shown that implants placed immediately in an extraction site exhibit osseointegration processes similar to that known for mature sites, both in terms of quality and quantity of newly formed bone [Barzilay et al. 1996]. Karabuda, in a morphometric and histological study on mandibular canines, found a BIC (Bone-Implant Contact, indicative of osseointegration) of 62.4% and 51.3%, at 8 weeks, in post- immediate extractives, treated respectively with implants coated in hydroxyapatite and with implants in plasma sprayed titanium [Karabuda et al. 1999]. Schulte was the first, in a study performed on humans, with an 8-year follow-up, to report 90% success rates for post-extraction implants [Schulte et al. 1978]. Block [Block 1991], in a retrospective study, showed success rates between 92.7% and 98.0%, in agreement with the values found by Grunder et al. [Grunder et al. 1999] and other studies in the literature [Gelb 1993; Polizzi

et al. 2000]. Studies in the literature on immediate implant placement in extraction sites of multi-rooted elements are scarce: Artzi et al. in a 5-year study showed success rates of 92% at the mandibular molar level and 82% at the level of maxillary molars, highlighting how the fundamental factor is bone density, with failure rates of up to 35-44% in D4 bone [Artzi et al. 2003].
In a 12-month follow-up study Cafiero et al. [Cafiero et al. 2008] achieved the same success rates between upper and lower molars (100%); data in agreement with the 18-month study by Van Bogaerde et al. [Vanden Bogaerde et al. 2005]. As demonstrated by these studies, the post-extraction implant procedure shows a high success rate and is therefore now considered a clinical procedure with predictable results.

Other studies have also shown that, in the insertion of immediate loading implants, guided bone regeneration techniques are not necessary to fill the gap between the implant and the alveolus, but that the site has the intrinsic ability to fill this bone defect (provided it is quite limited). For example, in a study by Becker, the implants were placed at the same time of extraction, within the boundaries of the alveolus, and no type of grafting material or barrier membrane was used. The small circumferential defects between the implants and the surrounding bone wall were filled with blood and covered with a pedunculated flap. A success rate of 93.3% at 4 years was reported by these authors [Becker et al. 2000]. The observed good clinical results have recently been confirmed by histological evaluations, limited to peri-implant bone defects of 2mm or less, in which the implants are placed immediately after tooth extraction without regenerative procedures; the degree of bone-to-implant contact did not differ from that of implants placed in mature, healed bone [Paolantonio et al. 2001].

A study by Covani et al. from 2003 supports the hypothesis that, to induce spontaneous bone healing in the peri-implant bone defect that does not exceed 2 mm, the following factors are sufficient:

- Primary stability;
- Integrity of the bone wall which maintains a stable blood clot;
- Closure by primary intention of the flap.

Coronal bone remodeling was also observed in this study: a thinning of the horizontal dimension of the ridge which can lead to difficulties in obtaining an aesthetically acceptable emergence profile for prosthetic rehabilitations on implants. Covani et al. have advanced the hypothesis that the extent of this remodeling could be decreased by the implants placed immediately after extraction [Covani et al. 2003]. However, this procedure still needs extensive and well-conducted studies to be accepted and recommended for routine use.

Indications and contraindications

In addition to the indications and contraindications common to all implant treatments, there are specific indications and limitations for immediate post-extraction implants. The main **indications** for the positioning of a post-extraction implant are represented by the need for a prosthetic restoration resulting from:

- Extraction of a dental element affected by a non-treatable pathology (extensive root caries; corono-radicular fracture; chronic endodontic lesions of the granulomatous type that persist after endodontic treatment).
- Extraction of an embedded dental element.
- Extraction of deciduous teeth in the case of permanent agenesis.
- Extractions in patients with high aesthetic demands. These patients will likely require immediate loading post-extraction implant placement.

The main **contraindications**, however, are:

- Active and symptomatic infection, with presence of pus and extensive osteolysis documented by radiographs. In the past, the presence of a chronic periapical infection was also considered one of the most important contraindications, however, during the last Consensus Conference [Hammerle et al. 2004] on the subject, the presence of a non-acute local infection was not indicated as a contraindication to immediate post-extraction implants. Already in 1997 Cosci & coll. presented a 7-year retrospective study in which the success of immediate post-extraction implant placement in infected sites was evaluated, achieving 99.53% success [Cosci et al. 1997].
- Anatomical conditions that do not favor the stabilization of the implant in an alveolus. In the upper maxilla the presence of the maxillary sinus in continuity with the root apex: this eventuality prevents extending the preparation apically (usually at least 4 mm) to obtain primary stability and forces the operator to resort to the use of larger diameter, in order to find the greatest possible bone-implant contact surface. In the mandible the presence of the mandibular canal in continuity with the root apex, for the same reasons explained above.
- The dental element to be extracted has globose roots that leave a post-extraction socket that is unlikely to be able to offer good primary stability to the implant.
- Extensive mucogingival defects that require a reconstruction of hard and soft tissues, which cannot be followed simultaneously with the insertion of the implant.

Advantages

The advantages of immediate post-extraction placement are represented by:
- Ideal placement of the implant for prosthetic purposes, although the surgical path left by the alveolus does not always guide correctly towards the ideal positioning of the implant abutment.
- Reduction in the number of surgical procedures, leading to: lower morbidity rate; reduction of the patient's psychophysical stress; reduction of restorative treatment times; decrease in the cost of treatment if no regeneration procedures are required.

- From a histological point of view, the immediate positioning of the implant favorably modifies the healing process of the alveolus, thanks to the reduction of the alveolar cavity and therefore of the volume to be filled with newly formed bone tissue.
- From the point of view of site preservation, the post-extraction implant helps to reduce tissue contraction, preserving the cortical plates and preventing the collapse of peri-implant soft tissues [Nemcovsky et al. 2002]. Schropp et al. in fact highlighted how the greatest bone volumetric changes occur during the first 12 months after tooth extraction, with a 50% reduction in bone volume, of which 2/3 within the first 3 months [Schropp et al. 2003]. The healing process of the socket with the implant abutment positioned inside has the same characteristics as the healing process of the extraction sockets, with the advantage that the amount of bone to be formed is less [Trombelli et al. 2008]. This prevention of initial bone loss allows the placement of wider and longer implants, which therefore offer greater stability.

Lastly, Hammerle & coll. in 2004 published a systematic review of the literature which highlighted the advantages of immediate or deferred implant placement, in relation to changes in the level of hard and soft tissues. For the type 1 implant the authors highlighted the following benefits: reduced number of surgical procedures; reduced total treatment time; optimal availability of native bone [Hammerle et al. 2004].

5c. Post-extractive dental implants in infected sites

The topic of post-extraction dental implants in infected sites is of great interest in recent times. In fact, we have seen the multiple advantages of type 1 implants; however, it is also necessary to consider the improvement of conservative techniques for saving even compromised teeth. Therefore, it is good

to note how we find ourselves increasingly often having to extract teeth with even persistent infections, as conservative dentistry treatments have failed. If the tooth is to be extracted, then bacterial contamination will almost always be considerable. This justifies the direction of the research towards the realization of a widely validated protocol for the placement of type 1 implants in infected sites.

A recent literature review examined studies conducted to verify the validity of this technique. In particular, the purpose of the study was to address the following question: “for patients who need immediate implant treatment in the esthetic zone, does the insertion of a dental implant into an infected site hold more risks than insertion into a healthy site, and what can be done during the treatment to improve the prognosis?” [Chen et al. 2018]. Of the 9 included, 6 studies were conducted to assess whether immediately placed implants in sockets with or without periapical pathology showed any differences regarding survival rates. In 1 study, the prognosis for immediate dental implants placed in fresh sockets with or without periodontal lesions was investigated. The other 2 studies analyzed the treatment outcomes of immediate implant placement in sites with periodontal or periapical pathology. The meta-analysis relating to the review includes a total of 1735 participants (infected group n=758; non-infected group n=977). Results showed that, compared with the healthy controls, immediate implant placement into infected sites with periodontal or periapical pathology in the esthetic zone had an equally favorable survival rate, with similar soft and hard tissue changes. In addition to this encouraging information, another very important data emerges from this review: control of contamination in the extraction sites may be the key to success of implant type 1 in infected sites. During surgery, even after thorough irrigation, pathogenic bacteria can remain and live in sites because of self-encapsulated biofilms. Once again, the toilet of the socket is therefore essential. As regards the methods of curettage used, only one study out of nine proposed the use of the laser while the others suggested a traditional debridement. Many studies also included postoperative chlorhexidine rinses and antibiotic prophylaxis. Although it is still controversial whether systemic

antibiotics are needed before or after the implant placement, until more evidence proves otherwise, systemic antibiotics are recommended in the treatment plan, especially for patients with poor surgical conditions or when complex procedures like GBR are performed. Most of the studies included in this review adopted GTR or GBR as the treatment method; this is because the infected sites are often associated with bone resorption processes and periodontal defects. The review's conclusions affirm that immediate implant placement into infected sites and noninfected sites in esthetic zone had similar survival rates, bone level changes, and gingiva level changes.

Among the researches analyzed in the review just described, the most recent is a multi-center retrospective study conducted by Zuffetti et al. where they had recorded a series of patients who underwent extraction and immediate implant placement into both infected and non-infected sites from January 1998 to September 2014 at 5 different dental centers considered for inclusion [Zuffetti et al. 2017]. Again, the conclusions encourage the use of implants in infected sites and further assert that the origin of the infection, whether periodontal or endodontic, has no effect on the implant survival, confirming previous observations on survival rates of implants immediately placed into sites where the infection was of endodontic origin [Corbella et al. 2013]. Moreover, the long-term success rate of implants in this study that were followed for a longer time period strongly suggests that the loading protocol has no effect on the survival of implants placed in periodontally or endodontically infected sites, even over a longer time range. However, the big limitation of this study is represented by the fact that no measurements concerning peri-implant bone levels were collected.

Despite the success rate of implants in infected sites, it is worth mentioning a review prior to the first mentioned that highlights a couple of important aspects [Chrcanovic et al. 2013]. The first aspect concerns the survival of the bacteria in the alveolar bone even after extraction. Bacteroides forsythus has been shown to persist in asymptomatic periradicular endodontic lesions and may survive in bone

in an encapsulated form after extraction and subsequently could infect an implant [Siqueira et al. 2001]. Ayangco and Sheridan reported three patients who had a history of failed endodontic and apicoectomy procedures, which finally led to extraction of the involved teeth and subsequent placement of implants after sufficient healing time. Even after thorough and vigorous debridement and irrigation of the extraction sockets and the passing of sufficient healing time, bacteria had remained in the bone, which led to the initiation of retrograde peri-implantitis [Ayangco & Sheridan 2001]. Brisman et al. reported that even asymptomatic endodontically treated teeth with a normal periapical radiographic appearance could be the cause of an implant failure [Brisman et al. 2001]. The other aspect that emerges from Chrcanovic's review is the fact that the use of an erbium laser using photoacoustics to reduce the bacteria in osteotomy sites, that were infected by apical pathology, was applied only in one study with 10 patients without a control group. So, more research is needed concerning this issue.

In a very recent narrative review, Chang describes the implant periapical lesion (IPL) that is an infectious-inflammatory alteration surrounding an implant apex [Chang 2021]. Implant periapical lesion, with a multifactorial etiology, is an infectious-inflammatory lesion surrounding the implant apex; prevention is obviously the best treatment, and the incidence of IPL could be reduced by detailed examination before dental implant therapy and careful surgical technique. Besides the author highlights how the use of lasers, such as Er,Cr:YSGG laser, is advantageous because of its bactericidal effect on oral pathogens and the ability to reach anatomically complex areas [Kusek 2011; Soldatos et al. 2018]. Currently, lasers including Er-Cr:YSGG and Nd:YAG, are used as adjuncts for the debridement after extraction, especially during immediate implant placement [Crippa et al. 2020]. Laser has been demonstrated to be superior to chemical treatment. To alleviate concerns of IPL, it may be helpful to decontaminate with laser the socket after tooth extraction and to sterilize the site before implant placement.

Although the post extraction implant placement technique has been widely validated, little has been reported concerning the applications of laser decontamination of the infected sites for immediate implant placement. A search through the published studies produced only five clinical articles that combined laser treatment and immediate implant therapy (Table 1.1). Kusek presented 10 cases of immediate implant placement subjected to the Er,Cr:YSGG laser disinfection therapy and affirmed that these cases would have taken 3 times longer to heal if treated through traditional methods. Using this technique would therefore enable both the patient and the dentist to benefit from a reduced treatment time [Kusek et al. 2011; Crippa et al. 2020].

Author	**Study design**	**Infected sites**	**Laser**	**Implants (no.)**	**Follow-up**	**Survival rate**
Kusek	Case series	Yes	Er,Cr:YSGG	10	1 year	10/10
Montoya-Salazar et al.	Prospective	Yes	Er,Cr:YSGG	18	3 years	17/18
Crippa et al.	Case series	Yes	Er,Cr:YSGG	94	6 months/4 years	89/94
Choi et al.	Case series	No	Nd:YAG	6	9 months	6/6
Kakar et al.	Case series	Yes	Er,Cr:YSGG	110	4 months/5 years	105/110

Table 1.1. Articles about laser treatment and immediate implant therapy.

Montoya-Salazar et al. also reported a similar study: they analyzed 36 immediate implants replacing teeth lost due to chronic periapical lesions, with a history of endodontic failure, and concluded that this therapy may be considered a safe option to restore fresh infected post extraction sockets, provided that a strict debridement protocol was respected. Their protocol comprised curettage, cleansing with 90% hydrogen peroxide, irradiation with Er,Cr:YSGG laser, and chlorhexidine rinses, together with guided bone regeneration under antibiotic cover [Montoya-Salazar et al. 2014]. Crippa et al. described a series of 94 post extraction implants with a follow-up from 6 months to 4 years and a success rate of 94.6% (89/94) [Crippa et al. 2020]. Additionally, Choi et al. described the advantages of using the laser for ridge conservation. However, that study was not pertinent to infected sites. The authors

affirmed that using the Nd:YAG laser energy with 650 μs pulse duration consistently supported rapid clot formation and graft containment at immediate implant and ridge preservation sites [Choi et al. 2019].

The most recent study on this subject is that of Kakar et al. Their retrospective record review was used to identify 68 patients who had implants placed as per the described protocol. A total of 126 implants were placed in 68 patients (65 implants in the maxilla, 61 implants in the mandible). The implants were loaded 136 ± 73 days (mean ± standard deviation; range: 37–400 days) after implant placement. Eight patients (16 implants) were subsequently lost to follow up. The results show 105 of the 110 implants (95.45%) placed immediately in the infected sites using the laser protocol survived after prosthetic loading [Kakar et al. 2020].

5d. Lasers use in Dentistry and in Dental implantology

The creation of the very first laser is due to Maimann which, in 1960, gave birth to a pulsed ruby laser which emitted at 694 nm. The first applications of the laser in the dental field was in the early 60s with the use of lasers a ruby, which however produced harmful thermal effects. At that time there was still no precise knowledge on action targets and on the absorption curves of the various laser wavelengths [Maggioni et al. 2021]. The introduction of laser technology in oral surgery soft tissue is due to the collaboration between oral and maxillofacial surgeons and otolaryngologists. In 1987 the FDA first gave permission to use a laser technology in oral surgery.

At the end of the 1980s there was an epochal revolution, with the development of Er:YAG lasers which, through their affinity elective with water, allowed an enormous capacity for use in dentistry and dermatology [Keller et. al. 1997].

The wavelength is the most important parameter of a laser. Lasers in the medical field practically cover the whole spectrum of electromagnetic radiation, while in dentistry the most used ones are

found in visible and in the near and mid infrared (fig. 1.2). The lasers primarily used in implantology are semiconductor diode lasers; solid state laser Nd:YAG, Nd:YAP, Er:YAG, Er,Cr:YSGG; and gas lasers, like the CO_2 lasers (table 1.2). Diode lasers, CO_2, and Nd:YAG and Nd:YAP lasers may be used for soft tissue applications having excellent coagulation properties; Er:YAG and Er,Cr:YSGG lasers are the representatives for the hard tissue applications due to the high absorption from hydroxyapatite [Romanos et al 2013].

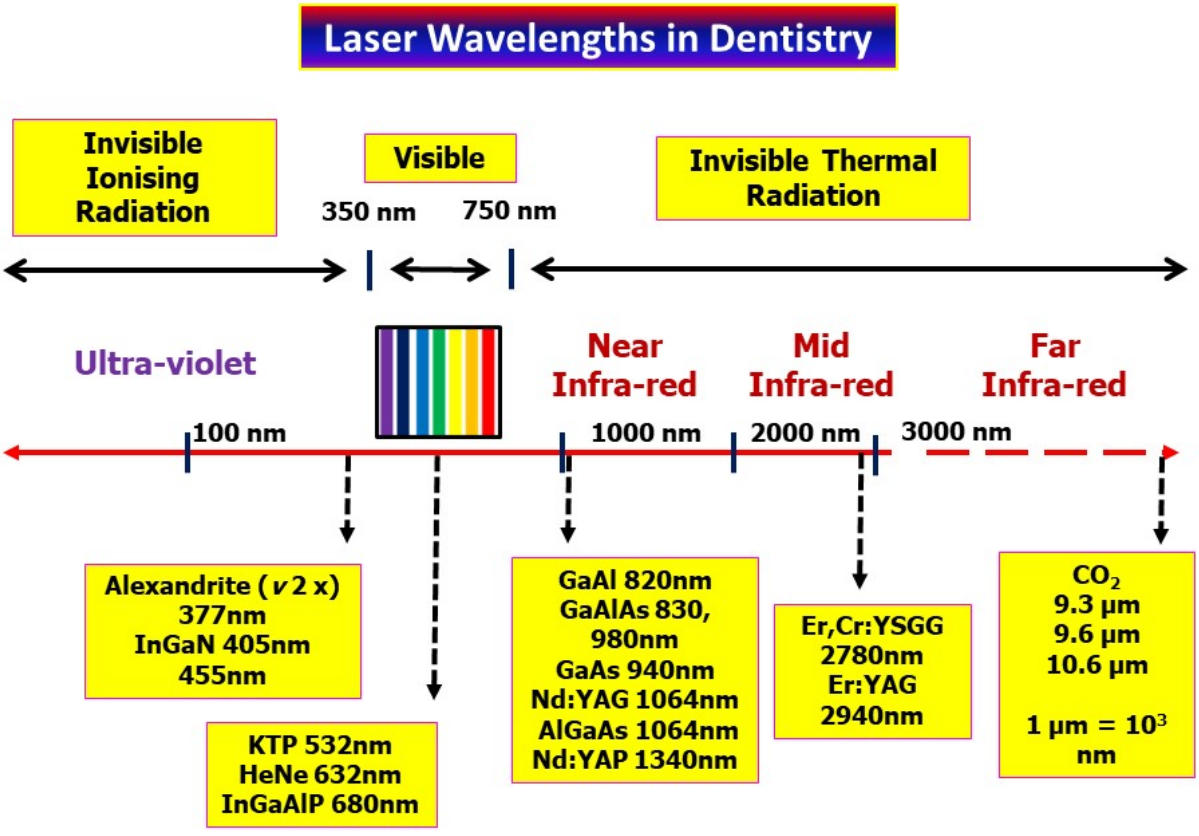


Figure 1.2. Laser wavelengths in common use in clinical dentistry. Adapted from Parker et al. Current Concepts of Laser-Oral Tissue Interaction. Dent J (Basel). 2020 Jun 28;8(3):61. Courtesy of dr. Steven Parker.

STUDY	Laser wavelength	Type of study	Effects
Kato et al	CO_2	In vitro	Bacterial reduction
Bach et al	Diode (810 nm)	Clinical	Pocket reduction
Romanos et al	Nd:YAG	In vitro	Significant melting
Romanos et al	CO_2	Clinical	Periimplantitis therapy
Arnabat-Dominguez et al.	Er:YAG	In vivo	Second stage surgery
Schwarz et al	Er:YAG	In vitro	Reduction in bleeding on probing
El Montaser et al	Er:YAG	In vivo	No thermal damage
Kelser et al	Er:YAG	In vivo	Better osseointegration
Lewandowski et al	Er:YAG	In vivo	Better healing than the drill
Pourzarandarian et al	Er:YAG	In vivo	Initial faster bone healing
Schwarz et al	Er:YAG	In vivo	Safe (but not better) healing compared with the control
Romanos et al	CO_2; Er,Cr:YSGG	In vitro	Attachment of osteoblasts
Deppe et al	CO_2	Clinical	Periimplantitis therapy
Dorbtbudak et al	Photodynamic therapy	In vitro	Bacteria reduction

Table 1.2. Effects of Lasers in Implantology. Adapted from Romanos GE, Gupta B, Yunker M, Romanos EB, Malmstrom H. Lasers use in dental implantology. Implant Dent. 2013 Jun;22(3):282-8.

The proposed advantages of the use of lasers in implant dentistry are improved hemostasis precise incision margin, minimal damage to the surrounding tissues, and reduced postoperative swelling. Furthermore, the effect of the laser is exploited for bacterial decontamination. In fact, numerous studies have demonstrated the effectiveness of the laser against different types of bacteria and for the treatment of periimplantitis [Romanos et al 2013].

Another important laser's advantage is called "low level laser therapy" (LLLT), also known as soft laser or biostimulation. This effect is a photochemical effect caused by the action of visible red (633-635 nm) or near infrared (810-830 nm) light on the electron transport chain in mitochondria, which activates NADPH oxidase (and other enzymes) in the inner mitochondrial membrane and causes a

broad activation of normal cellular functions. Many clinical studies (including randomized controlled clinical trials) have shown that biostimulation allows to improve the healing of soft tissues, accelerating closure of oral mucosal soft tissue and accelerates bone behavior in terms of integration and regeneration around implants [Walsh 2006].

There are applications for lasers in implant dentistry (fig. 1.3), including for second stage surgery, removal of peri-implant soft tissues, and decontamination of failing implants [Romanos 2015]. Several reviews of the literature of controlled clinical studies have verified the effectiveness of the laser in the treatment of peri-implantitis. In particular, a very recent meta-analysis network lists the erbium laser among the most effective in the treatment of peri-implantitis [Hu et al. 2021]. As a matter of fact, this result had already been demonstrated in the treatment of periodontal disease, where better short-term results were found compared to traditional therapy [Lin et al. 2018]; also in endodontics the laser is successfully used for the disinfection of root canals [Bordea et al 2020].

Figure 1.3. Er,Cr:YSGG laser.

It is interesting to note how after irradiation, clinically, no signs of any carbonization or melting were noted on the irradiated bone surface. Histological observation of the adjacent alveolar bone revealed no identifiable signs of any thermal side effects, such as carbonization, melting or cracking.

There are several possible benefits of applying low level laser therapy as part of surgical and postoperative therapy, such as suppression of the inflammatory processes, pain control and promotion of wound healing/ tissue regeneration [Aoki et al. 2015]. In the medical field, a meta-analysis of Woodruff et al. (341) reported that low-level laser therapy is an effective tool for promoting wound repair [Woodruff et al 2004].

Improvement of the surgical phases and the post-operative course, tissue stimulation for healing, bacterial decontamination and other advantages are among the reasons that push clinicians and researchers to deepen the application of lasers in oral surgery and implantology procedures. Together with the advantages of post-extraction implants, the laser represents a valid ally in daily clinical practice. However, there are no controlled clinical studies in the literature regarding post-extraction implants in infected sites and the use of lasers for decontamination.

MATERIAL AND METHODS

6. MATERIAL AND METHODS

6a. Ethical committee

This study received the approval of the ethics committee of the University of Valencia (n. 1606937298573) and it was performed in strict compliance with the STROBE statements (von Elm et al. 2008).

6b. Study design

A retrospective cohort study was performed. The study was based on a series of patients treated between 2014 and 2019 and with a minimum follow-up of 1 year up to over 4 years (the calculation of the sample size was not necessary as, being a retrospective study, all patients were included in the period indicated). The study was carried out at the Oral surgery department of the University of Valencia (Spain) in collaboration with the Istituto Stomatologico Italiano of Milan (Italy). The treated patients were informed and signed an informed consent explaining that their data could be used for educational purposes or used for research.

6c. Study Population

TEST GROUP (type 1 implants in infected sites treated with laser).

Inclusion criteria:

- Patients ≥ 18 years.
- No relevant medical conditions.
- Values of plaque index and bleeding on probing ≤ 25% for the whole mouth.
- Minimum follow-up of 1 year after implant surgery.

- Patients who received immediate implant therapy in infected sites (due to the presence of subgingival caries, periodontal disease, endodontic lesions or fracture) decontaminated with laser.

Exclusion criteria:

- Patients with important systemic diseases.
- History of radiotherapy.
- Current steroid treatment.
- Neurological or psychiatric disability.
- Immunosuppressed state.
- Patients with a history of treatment with bisphosphonates.
- Pregnant or lactating women.
- Severe bruxism.
- Patients with poor oral hygiene and uncooperative.
- Smoking (more than 15 cigarettes a day), drug or alcohol abuse.

CONTROL GROUP (type 4 implants in non-infected sites).

Inclusion criteria:

- Patients ≥ 18 years.
- No relevant medical conditions.
- Values of plaque index and bleeding on probing ≤ 25% for the whole mouth.
- Minimum follow-up of 1 year after implant surgery.
- Patients who received type 4 implant therapy for edentulism.

Exclusion criteria:

- Patients with important systemic diseases.
- History of radiotherapy.
- Current steroid treatment.
- Neurological or psychiatric disability.
- Immunosuppressed state.
- Patients with a history of treatment with bisphosphonates.
- Pregnant or lactating women.
- Severe bruxism.
- Patients with poor oral hygiene and uncooperative.
- Smoking habit (more than 15 cigarettes per day), drug or alcohol abuse.

This first phase of the study includes the selection of the x-rays (intraoral periapical x-ray taken with the positioning ring and the parallel technique) and the medical records of the included patients, to complete the drafted protocol. They were patients who received immediate dental implants placed in infected sites decontaminated with lasers or patients who received dental implants with traditional technique. Patients must have a minimum of 1-year follow-up. Additional exclusion criteria were: patients with important systemic diseases, history of radiation therapy, current treatment with steroids, neurological or psychiatric handicap, immuno-compromised status, bruxism, smoking habit (more than 15 cigarettes per day), drug or alcohol abuse and inadequate compliance.

6d. Material

- Clinical data collection protocol (annex 1).

- Material for implant surgery: surgical field isolation set and surgical aspirator, sterile gloves, cap, protective goggles and mask, anesthesia syringe, disposable anesthesia needle, anesthesia in Optocain® carpule (Mepivacaine 1: 100,000), intraoral mirrors, physiological serum, gauzes, field detachers and separators, Er laser, Cr: YSGG Waterlase iPlus® (Biolase, Foothill Ranch, USA), Straumann® implant surgical set (Basel, Switzerland), contra angle and surgical motor, tweezers dissection, needle holder, suture thread, scissors and periodontal probe.
- Biomaterials: in some cases an absorbable membrane (Collprotect®, Straumann®, Basel, Switzerland), Bio-Oss® (Woburn, MA, USA) and synthetic collagen (Septodont®, Mataró, Spain) were used.

- Prosthetic procedure: Straumann® implant prosthetic set, Duralay® resin, silicone, impression tray.

- Iconographic material: NIKON® D7500 digital camera (Tokyo, Japan), ring flash and intraoral mirrors.

- Radiological examination: Heliodent Plus Dentsply Sirona® and ring positioner for standardization of Rinn® XPC projections (Dentsply®, Ilinois, France).

- Radiological analysis: medical screen with a resolution of 1920 x 1080 and with EIZO® magnification (7x).

6e. Methods

Clinical procedures

- Pre-surgical preparation.

A meticulous history and clinical examination were performed. An intraoral or panoramic radiograph was performed; A cone beam computed tomography was requested when considered necessary by the surgeon to assess bone volume. Diagnostic models were obtained to establish a correct diagnosis and carry out surgical and prosthodontic planning.

- Antibiotic prophylaxis.

Treatment with amoxicillin, 1 gr. twice a day for 6 days, starting the night before surgery. This was done in both the test group and the control group.

- Implant surgery.

All the patients consented to a treatment plan involving the extraction of a compromised tooth, decontamination of the site using the Er,Cr:YSGG laser, and the placement of a fixture in the same clinical session, in order to replace the missing tooth (test group). The treatment plan was agreed upon after a careful analysis that excluded the presence of contraindications, such as poor oral hygiene or smoking. The patients gave their informed consent for data processing.

The surgical phase included an antibiotic therapy (amoxicillin, 1 g twice daily for 6 days) that started the evening before surgery. The local anesthetic used in the interventions was Optocain® (Mepivacaine 1:100.000). The following images show the salient phases of the surgical protocol for post-extraction implants in infected sites decontaminated with the Er,Cr:YSGG laser through an example case (fig. 2.1). The compromised teeth were extracted as atraumatically as possible to safeguard the surrounding tissues, assisted by the Er,Cr:YSGG 2780 nm laser. As can be seen from the initial radiograph (fig. 2.2), elements 3.1 and 4.1 were extracted due to a fracture.

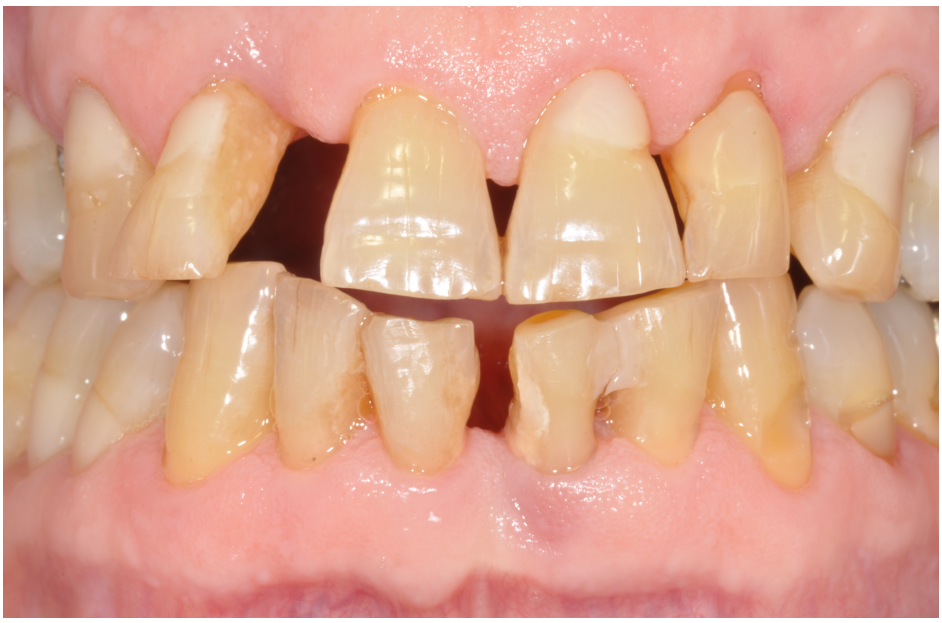
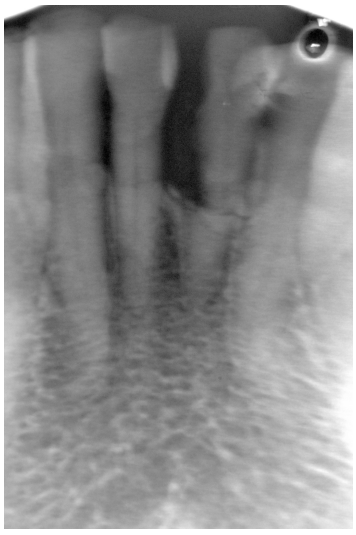


Figure 2.1. Preoperative clinical situation.

Figure 2.2. Preoperative x-ray showing the root fracture of 3.1 and 4.1.



The full-thickness flap (fig. 2.3) was raised by the laser with the following settings: configuration for the soft tissue mode, which included tip MC-3, length 9mm, air 20%, and water 80%. For bone tissue, the setting mode included tip MZ-8, length 6mm, air 40%, and water 60%. Once extraction was completed, the decontamination phase of the infected site began.

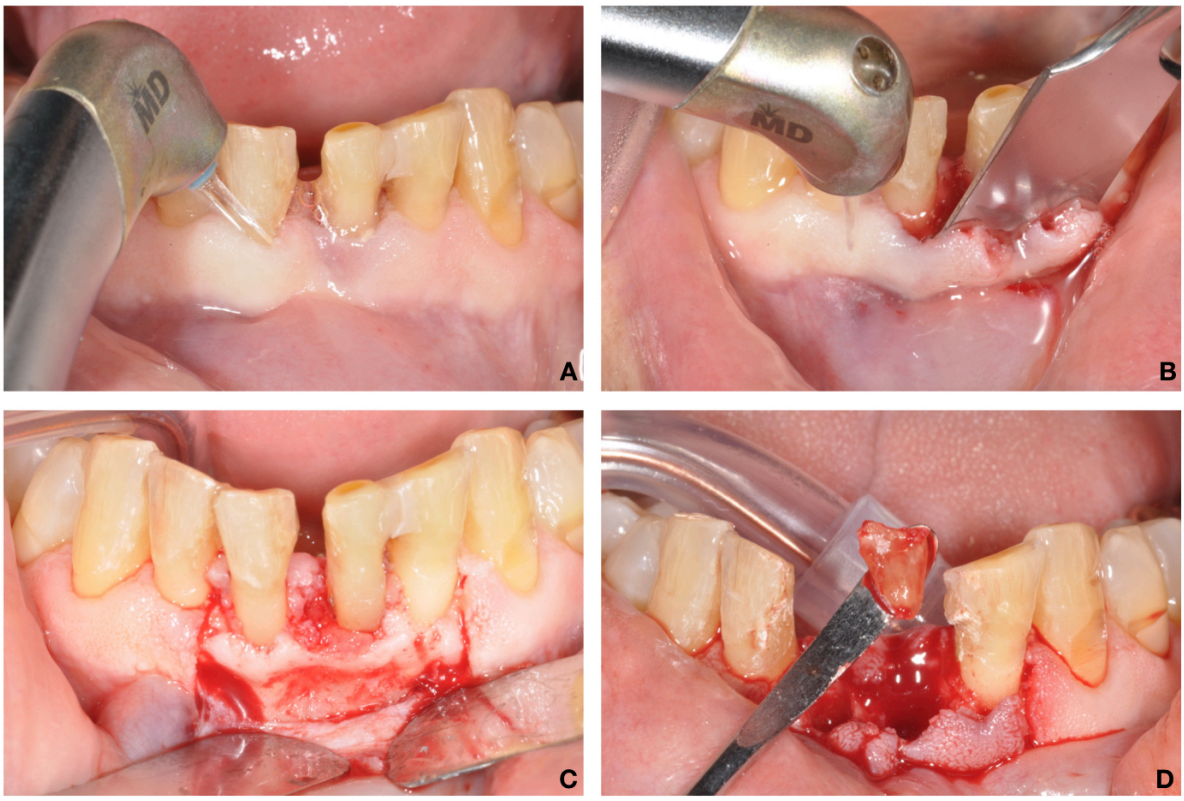


Figure 2.3. Execution of the surgical flap with the laser and atraumatic extraction of 3.1 and 4.1.

The site was debrided and decontaminated (fig. 2.4) after extraction using the same laser device but with another setting: 2.0W, 20% air, and 80% water, while mounting a MZ-6 tip, 9mm in length. Debridement time depended on the amount of pathological tissue and bone volume, whereas decontamination lasted from 60 to 90 seconds per socket, ensuring no physical contact between the tip and the tissues. The Waterlase iPlus® (Biolase) device was used for all laser procedures.

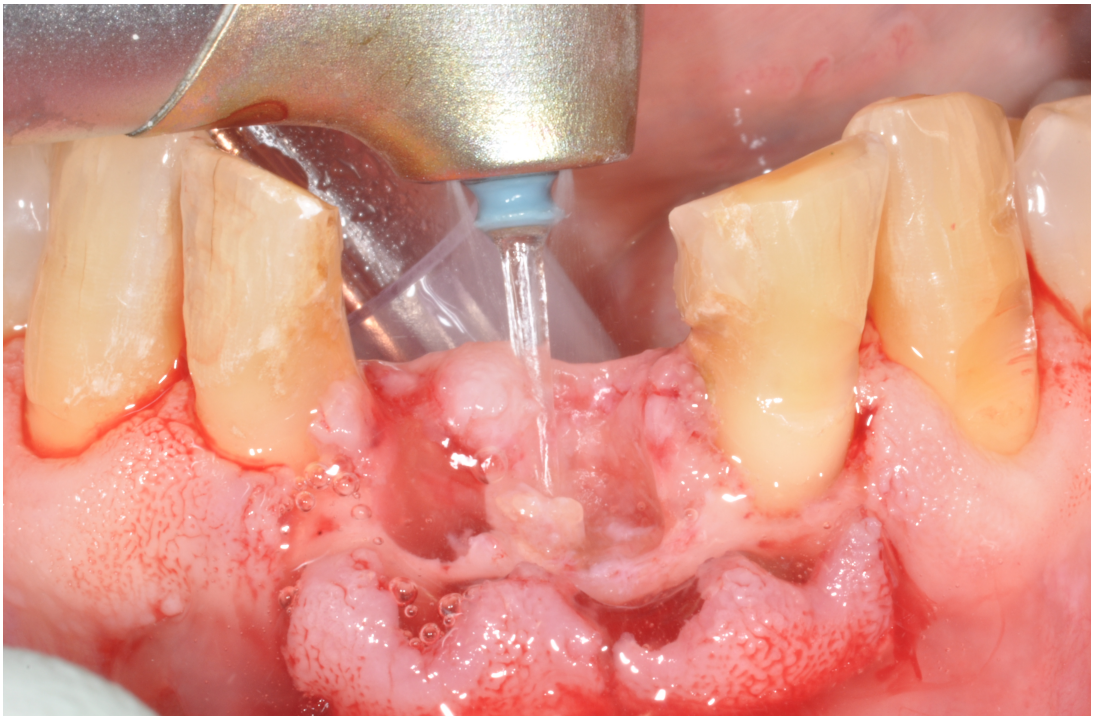


Figure 2.4. Laser decontamination of the infected site.

The subsequent phases of the intervention involved the placement of the implants (Straumann®). The fixtures were placed with a minimum 35N torque and 1mm below the most apical bone peak (fig. 2.5).

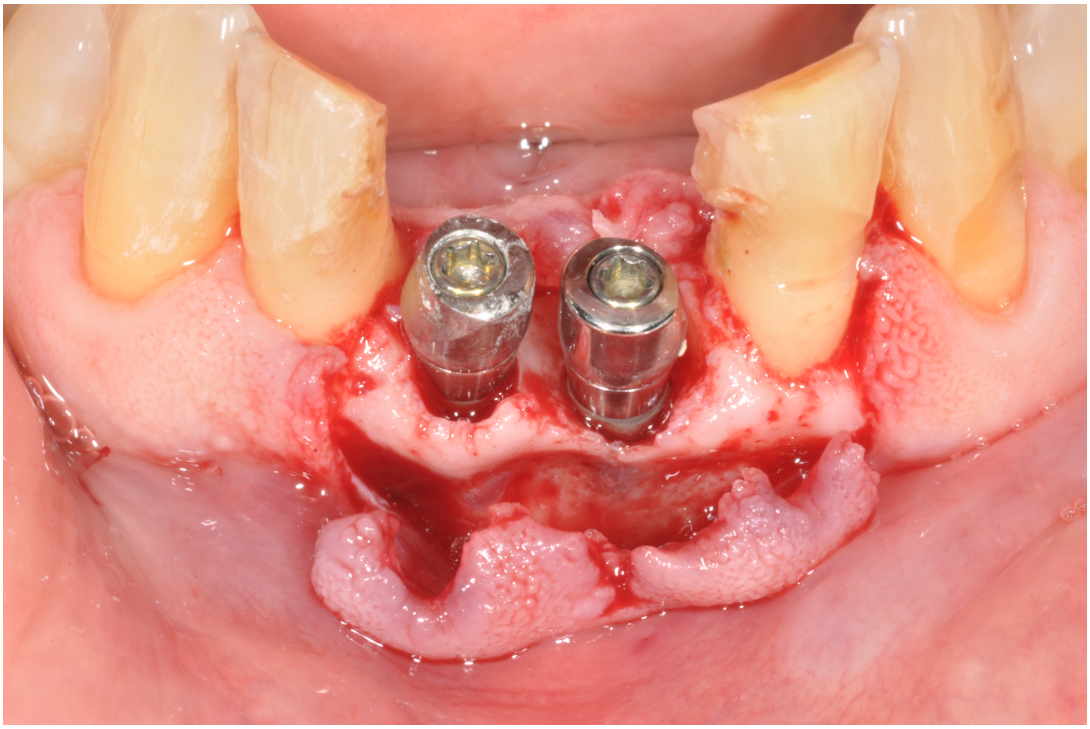


Figure 2.5. Immediate implant placement.

Often, it was also necessary to place biomaterials for the residual defect caused by the infection, as in this example case: an absorbable membrane (Collprotect®) and Bio-Oss® were used to improve tissue healing (fig. 2.6). In some cases also synthetic collagen (Septodont®) was used. Sutures (PTFE 3/0 Gore®) were placed with particular care to obtain good flap repositioning (fig. 2.7). Subsequently, chlorhexidine gluconate gel 0.2% twice daily for 15-20 days was prescribed, and post-operative instructions were given to the patient. Periodic clinical and radiographic checks (fig. 2.8) were scheduled, and the implants were loaded immediately or after 3 months.

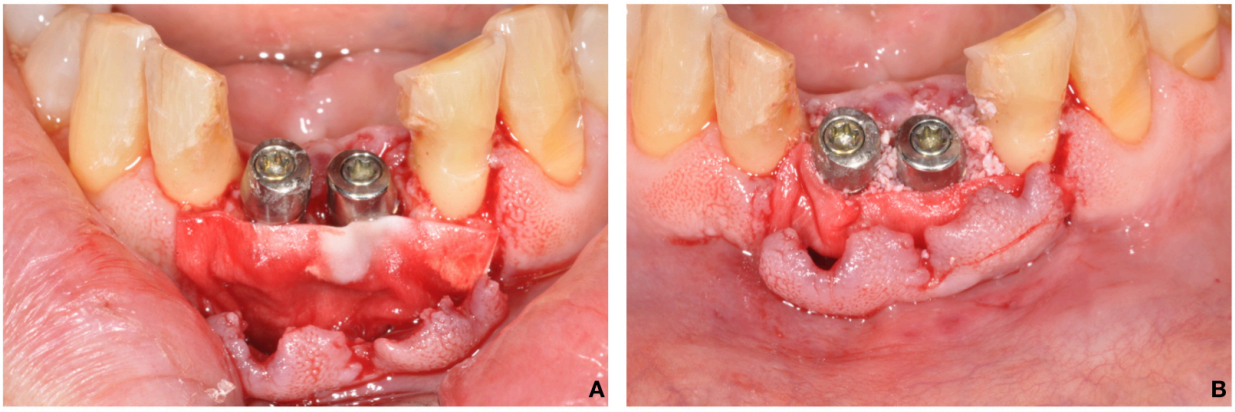


Figure 2.6. The use of biomaterials was necessary for the management of bone gaps.

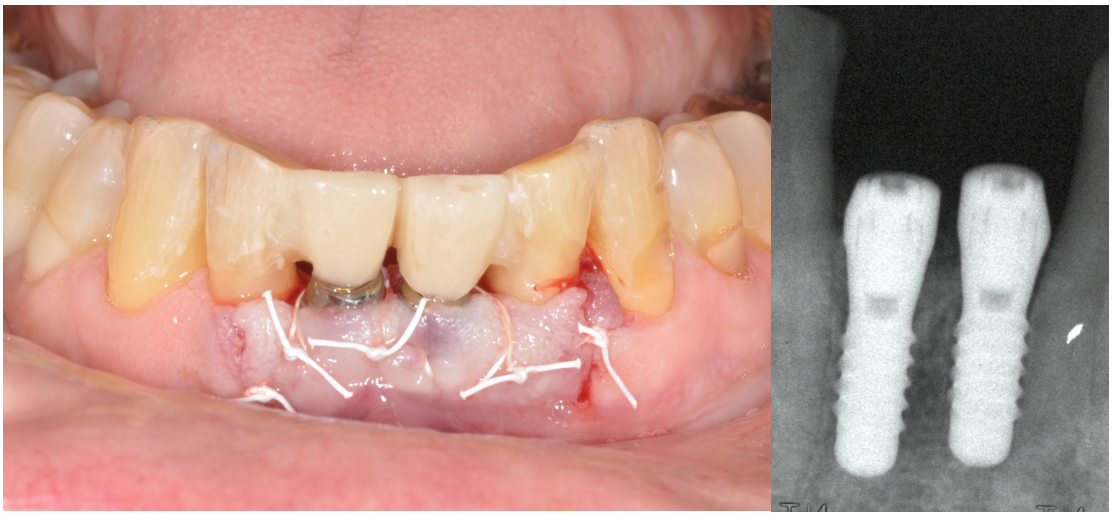


Figure 2.7. Suture.

Figure 2.8. Postoperative x-ray.

Patients in the control group had followed a similar implant protocol, but tooth extraction had taken place at least 3 months earlier and there was not performed a laser decontamination of the site.

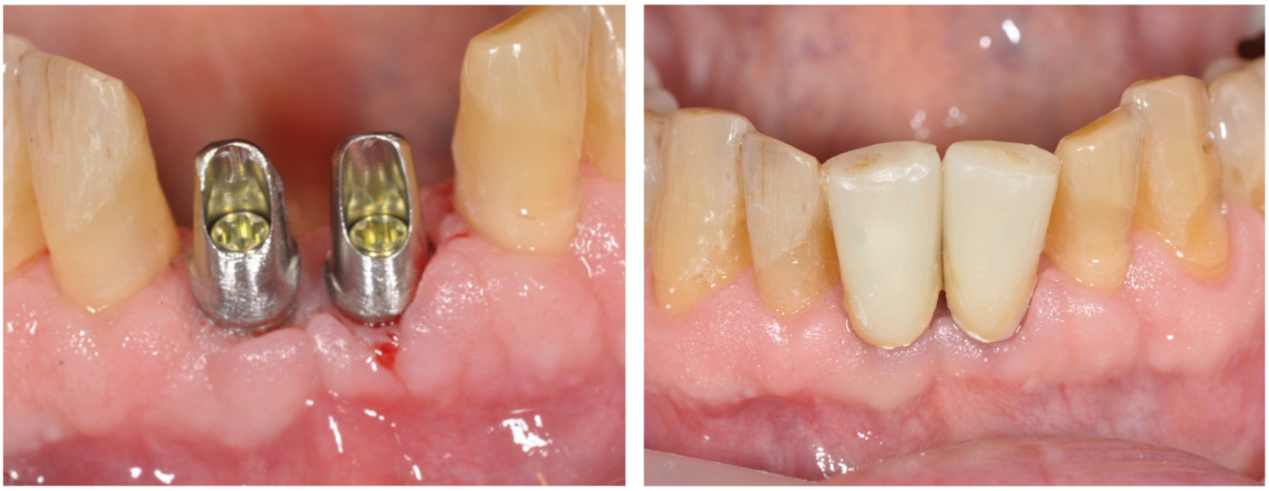


Figure 2.9. Provisional prosthetic phase after 3 months.

The example case was completed first with a provisional phase (fig. 2.9) and then with the final cemented metal-ceramic crowns (fig. 2.10 and 2.11).

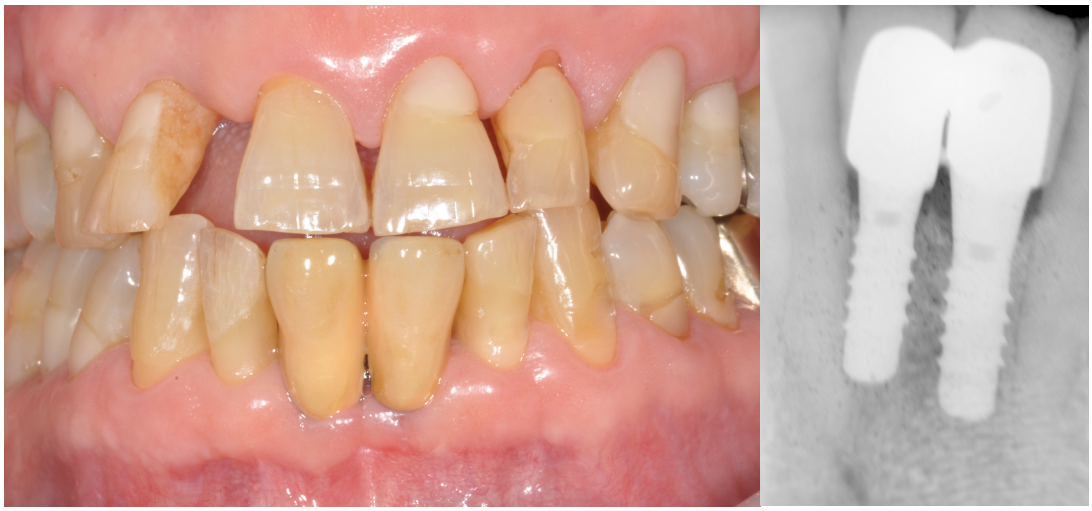


Figure 2.10. One-year clinical follow-up.

Figure 2.11. One-year radiographic follow-up.

- Prosthetic phase.

The implants were loaded immediately or after 3 months. In this case, the implants were not loaded immediately, but the provisional phase was managed with a Maryland bridge. The possibility of immediate loading was decided based on some clinical parameters such as the primary stability of the implant according to the patient.

The second phase of this study includes the measurement of digital radiographs by a blind operator (R.A.) with a specific software (Image J, National Insitute of Health, Bethesda, Rockville, MA, USA). The following parameters had been used for radiographs: 65-90 kV, 7.5-10 mA and 0.22-0,25 s. Before measurement, each radiograph was calibrated by using the implant diameter and length as reference measures to correct any distortion. The radiographs were measured on a medical screen with a resolution of 1920 x 1080 and with magnification (7x). Marginal Bone Level (MBL) was measured for baseline and follow-up according to Linkevicius et al., calculating the distance between the implant neck and the first bone-to-implant contact [Linkevicius et al. 2009], and taking into consideration both mesial and distal aspect of each implant (figure 2.12).

Radiographic analysis

For the radiographic analysis, an intra-rater agreement was carried out. An a-priori independent sample of 20 measured implant surfaces were measured twice, 2-weeks apart. The two-way intra-class correlation coefficient for radiographic intra-rater agreement analysis was 0.97 (95%CI from 0.95 to 0.99).

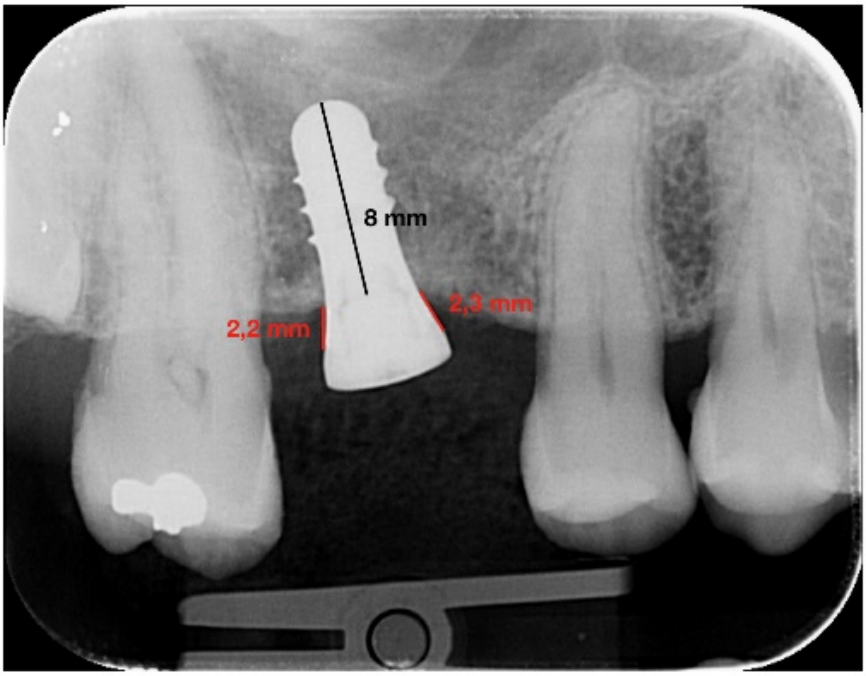


Figure 2.12. Example of x-ray measurement for MBL: it was measured calculating the distance between the implant neck and the first bone-to-implant contact. In the example, 8 mm was the length of the implant used for calibration, while 2.3 and 2.2 mm indicate the mesial and distal MBL measurement respectively.

Statistical analysis

The mean and standard deviations for the quantitative variables and the frequency and percentages for the qualitative variables were used as descriptive statistics. The unit of analysis was the implant, despite the fact that often multiple implants were used for each patient.

A mixed statistical model was used for the outcome variable difference in MBL using the patient as a random effect. The covariate was the MBL at baseline and the group (test or control implant) was the explanatory variable (fixed effect).

To compare the differences at baseline between the two groups (test implants versus control implants) mixed effects models were used for the quantitative variables age, implant length, implant diameter, MBL at baseline. A mixed effects model was also used to compare the duration of follow-up between

the two groups. The patient was the random effect (random effect) and the group (implant test or control) was the explanatory variable (fixed effect).

In order to compare the differences at baseline between the two groups (test implants vs. control implants), multilevel models were used for the qualitative variables: gender, smoke, arch (upper or lower), area (frontal - incisors or canines – vs. posterior -premolar or molar-), extraction reasons (fracture vs. other), presence of abscess or fistula, presence of lesion, implants with narrow neck, immediate loading, use of membrane, use of collagen, use of synthetic bone. The models were at two levels (patient and implant) and the group (test implant or control) was the explanatory variable. The significance threshold was set at 0.05. The statistics were performed with the JMP v. 13.0 and with MLwin v. 3.05.

RESULTS

7. RESULTS

7a. Results of the retrospective clinical study

Overall, 98 patients with an average age of 58.0 ± 14.6 years (21 to 88 years), 52 females (53%) and 46 males (47%) were treated; there were a total of 22 smokers in the sample (22%); a total of 149 implants were placed, 90 (60%) were type test and 59 (40%) control.

Only test implants were placed in 53 patients (1 implant in 35 patients, 2 implants in 10 patients, 3 implants in 4 patients, 4 implants in 3 patients and 5 implants in 1 patient). Only control implants were placed in 39 patients (1 implant in 29 patients, 2 implants in 7 patients, 3 implants in 3 patients). Both test and control implants were placed in 6 patients (1 test implant and 1 control implant in 5 patients, 1 test implant and 2 control implants in 1 patient).

Baseline

Patient-related variables at baseline are shown in Table 2.1, that shows gender, age and smoking habit in the different groups. The table refers to patients who had at least one implant of the considered type.

The variables relating to the site are shown in Table 2.2, that includes different characteristics relating to the implant: upper or lower arch, zone (anterior o posterior), reason for the extraction (fracture, no fracture, abscess or fistula), presence and dimension of periodontal lesion, use of implant with narrow neck, implant length, implant diameter, use of immediate loading, use of membrane, collagen or synthetic bone, misurement of MBL baseline.

Table 2.1. Patient-related baseline characteristics.

Variable	Test group N=59	Control group N=45	P-value
Gender (female) (%)	29 (49%)	25 (56%)	0.764*
Gender (male) (%)	30 (51%)	20 (44%)	0.764*
Age (years) (sd)	59.3 (14.5)	57.5 (14.5)	0.977**
Smoker (%)	13 (22%)	9 (20%)	0.913*

sd: standard deviation. * Multilevel model; ** Mixed model.

Table 2.2. Baseline characteristics relating to the implant.

Variable	Test group N=90	Control group N=59	P-value
Upper arch	47 (52%)	25 (42%)	0.279*
Lower arch	43 (48%)	34 (58%)	0.279*
Zone (anterior)	26 (29%)	9 (15%)	0.201*
Zone (posterior)	64 (71%)	50 (85%)	0.201*
Extraction (fracture)	43 (48%)	31 (52%)	0.987*
Extraction (no fracture)	47 (52%)	28 (48%)	0.987*
Abscess or fistula	61 (68%)	42 (72%)	0.866*
Lesion	20 (22%)	2 (3%)	**0.007***
Narrow neck	12 (13%)	10 (17%)	0.563*
Implant length mm (sd)	9.9 (1.7)	8.9 (1.7)	**0.001****
Implant diameter mm (sd)	3.9 (0.4)	4.0 (0.5)	0.232**
Immediate loading	21 (23%)	8 (14%)	0.534*
Membrane	69 (77%)	30 (51%)	**0.047***
Collagen	21 (23%)	22 (37%)	0.324*
Synthetic bone	55 (61%)	18 (31%)	**0.011***
MBL baseline mm (sd)	2.4 (1.3)	2.4 (0.8)	0.912**

sd: standard deviation. * Multilevel model; ** Mixed model.

In the test group there were more often lesions, the implant length was greater than about 1 mm, the membrane and synthetic bone were more frequently used. In particular, the reasons for extraction in the test group were: caries (it means a subgingival caries and without the possibility of saving the tooth) for 32 teeth (36%), endodontic lesions for 10 teeth (11%), fracture for 43 teeth (48%) and

periodontal problems (teeth with periodontal disease and degree II or III of mobility) for 5 teeth (6%); and in the control group: caries (it means a subgingival caries and without the possibility of saving the tooth) for 20 teeth (34%), endodontic lesion in only 1 case (2%), fracture for 31 teeth (52%) and periodontal problems (teeth with periodontal disease and degree II or III of mobility) for 7 teeth (12%).

All the implants placed were Straumann, but with different characterticts to be adapted to all clinical situtations (fig. 3.1). In the test group, the following type of fixtures were used: 33 implants TE RN Loxim SLA Roxolid (37%), 37 implants S RN Loxim SLA Roxolid (41%), 4 implants SP RN Loxim SLA TiZr (4%), 3 implants SP NNC SLAactive TiZr (3%), 4 implants S RN SLAactive Roxolid (4%), 9 implants SP NNC Loxim SLA Roxolid (10%). In the control group, instead, the fixtures were: 6 implants TE RN Loxim SLA Roxolid (10%), 39 impnats S RN Loxim SLA Roxolid (66%), 4 implants SP RN Loxim SLA TiZr (7%), 0 implants SP NNC SLAactive TiZr (0%), 0 implants S RN SLAactive Roxolid (0%), 10 implants SP NNC Loxim SLA Roxolid (17%).

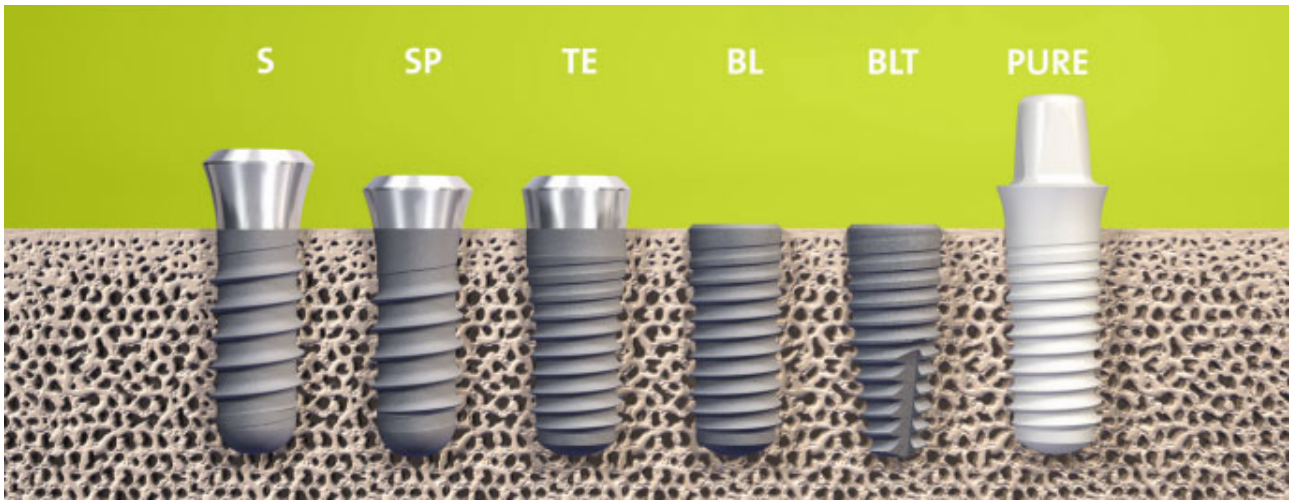


Figure 3.1. Types of fixtures used in the analyzed sample.

Follow-up

The follow-up was 1.7 ± 0.6 years in the test group and 1.5 ± 0.5 years in the control group, with a non-statistically significant difference (P = 0.082; Mixed model). There was only one failure in the test group (1%) and no failure in the control group. There was only one complication (mucositis) in the control group (2%) and no complications other than failure in the test group.

MBL results at follow-up are shown in Table 2.3, that includes the misurement at follow-up and the difference between baseline and follow-up.

Table 2.3. Marginal bone level (MBL) at follow-up.

Variable	Group Test N=89	Group Control N=59	Diff	95%CI	P-value
MBL at follow-up mm (sd)	2.3 (0.9)	2.5 (0.7)	0.2	0.0; 0.4	0.058*
MBL difference between baseline and follow-up mm (sd)	0.1 (1.0)	-0.1 (0.6)	0.2	0.0; 0.4	0.058*

sd: standard deviation. * Mixed model

The difference in MBL between the two groups is in favor of the test group which even gains 0.1 mm compared to the baseline while the control group loses 0.1 mm in MBL. However, the difference between the two groups is only 0.2 mm, which is not statistically significant (albeit slightly, P = 0.058).

7b. Clinical results

In addition to the statistical results, it was possible to obtain numerous clinical findings evidenced by radiographic and photographic documentation of the described technique.

During the follow-up visit, any complications were observed, such as implant loss, peri-implantitis, or loss of the peri-implant bone. Implants achieved a good primary stability (>35 N/cm). Prosthetic

rehabilitation after the surgical phase allowed us to obtain satisfactory function and esthetics. The success of implant therapy is highlighted by clinical and radiographic controls.

The technique requires a series of assumptions to be applied correctly and in a predictable manner:

1. The patient must be healthy, possibly non-smoker, and must not have untreated periodontitis. The patient must be co-operative and adhere to the dentist's instructions.
2. The clinical case must be carefully assessed in advance: the cause of tooth extraction, the possible presence of recurrent infections, the type of bone, etc. Therefore, evaluation of radiographs (and CBCT if appropriate) is also necessary.
3. Prophylaxis for surgery involves antibiotic therapy and chlorhexidine gel 0.2%.
4. The extraction must be completed atraumatically to preserve the residual bone.
5. Among the various types of lasers, Er,Cr:YSGG is recommended for the best decontamination capacity.
6. The use of biomaterials is often necessary to cope with bone defects.

There are several types of lasers available on the market. The reported settings are for the correct use of the Er,Cr:YSGG laser in different substrates (table 2.4). It is important to follow the programs of the device to avoid adverse effects to the hard and soft tissues. Operators must comply with all regulations for their own safety and for that of the patient, such as wearing special protective glasses.

Table 2.4. Laser setting.

Er,Cr:YSGG Laser	TIP	LENGHT	POWER	FREQUENCY	AIR	WATER
Soft tissue	MC-3	9 mm	3.5 W	50 Hz	20 %	80 %
Hard tissue	MZ-8	6 mm	3.5 W	20 Hz	40 %	60 %
Decontamination	MZ-6	9 mm	2.0 W	50 Hz	20 %	80 %

Two representative cases are reported below, one in the highly esthetic area and the other in the posterior sectors. The esthetic case concerns a 40-year-old woman with a compromised upper left lateral incisor presenting with clinical and radiological signs of an infection, particularly periapical periodontitis (fig. 3.2 A and B). The tooth had been unsuccessfully treated with apicectomy. The patient was in good general health and had a good oral hygiene and was motivated to begin the treatment of postextraction implant in an infected site decontaminated with laser.

The surgical phases followed the protocol previously described and a full thickness flap was carried out by a crestal incision with vertical releases (fig. 3.2 C). The postextraction site was treated with the Er,Cr:YSGG 2780nm laser device Waterlase iPlus® (Biolase) with the different configuration according to the required function. The implant (1 T.E. ø 3.3mm RN, SLA®; 10mm, Roxolid®) was inserted with a minimum 35N torque and 1mm below the most apical bone peak. Bio-Oss® and matrix barrier were used to improve bone healing (fig. 3.2 D and E). The suture was placed with particular care to obtain primary closure over the implant. The suturing material used was PTFE Omnia 3/0, 19mm 3/8. The temporary prosthetic phase before loading was managed with a Maryland bridge. The implant was loaded after 4 months, and a clinical check 2 years later demonstrates satisfactory esthetic outcomes (fig. 3.2 F and G). Radiographic checkups were scheduled on the 1st, 4th, 8th, and 12th months in the first year.

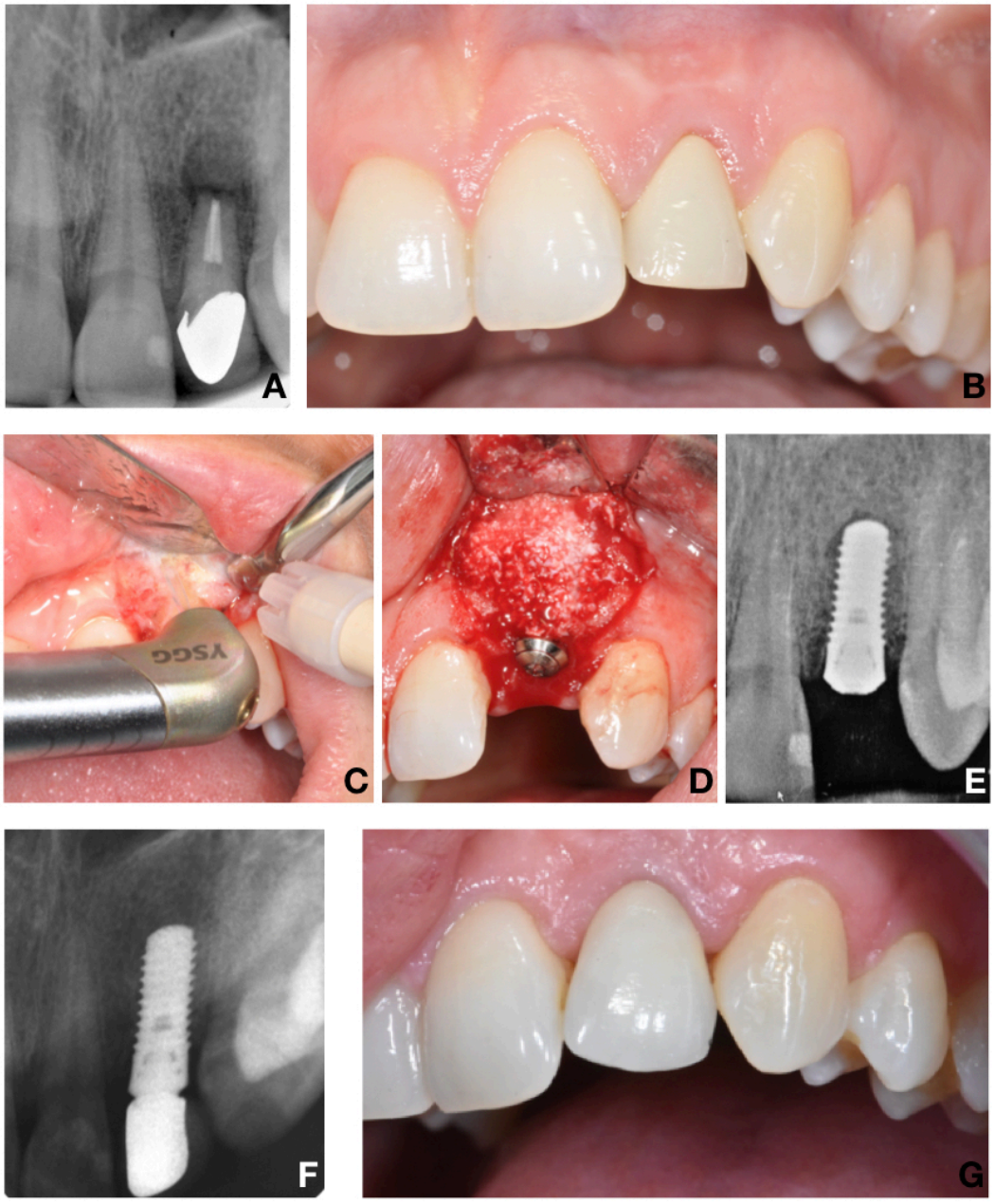


Figure 3.2. A clinical case of the sample in the esthetic zone with 5-year follow-up.

In the 5-year control cone beam it is possible to observe the absence of peri-implant lesions as well as the stability of the bone tissue after loading (fig. 3.3).

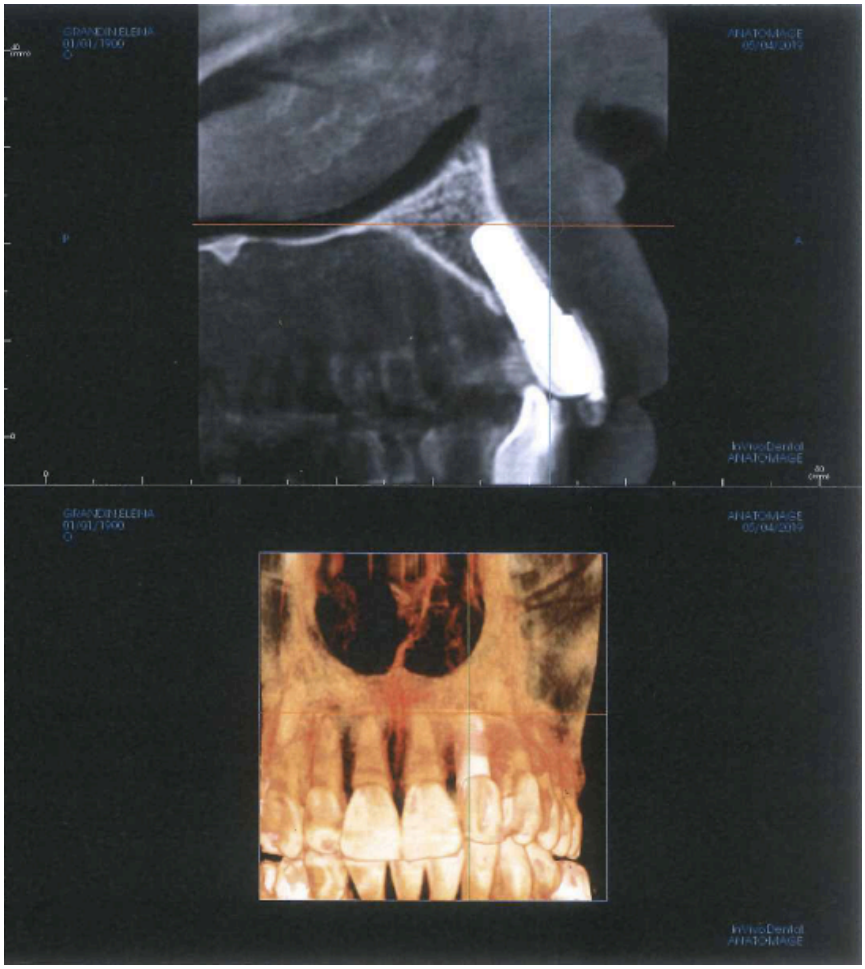


Figure 3.3. 5-year follow-up with CBCT.

In another representative clinical case, it's possible to observe the same laser technique applied in a posterior case. This clinical case concerned a 61-year-old female patient, who presented with pain in the mandibular left first molar (36), which was a prosthetic element of a bridge (fig. 3.4 A). The patient was a nonsmoker in good general health, and she had no significant medical history. Clinical examination, periodontal probing, and radiographs suggested a root fracture in tooth 36. The patient consented to a treatment plan involving the extraction of the compromised tooth, decontamination of the site using the Er,Cr:YSGG laser, and the placement of two fixtures in the same clinical session, in order to replace the missing tooth 35 and the compromised tooth 36 with a fixed implant prosthesis. The treatment plan was agreed upon after a careful analysis that excluded the presence of contraindications, such as poor oral hygiene or smoking.

With the same surgical protocol, after sectioning the bridge, tooth 36 was extracted as atraumatically as possible to safeguard the surrounding tissues, assisted by the Er,Cr:YSGG laser (fig. 3.4 B and C). Once extraction was completed, the decontamination phase of the infected site began (fig. 3.4 D). The subsequent phases of the intervention involved the placement of two implants. The fixtures (SLActive® S, Ø 3.3mm, RN, 10mm length to replace tooth 35 and 8mm to replace tooth 36) were placed with a minimum 35N torque and 1mm below the most apical bone peak. It was also necessary to place biomaterials for the residual defect caused by the infection: collagen (Septodont®) and an absorbable membrane (Collprotect®) were used to improve tissue healing. Sutures (PTFE 3/0 Gore®) were placed with particular care to obtain good flap repositioning (fig. 3.4 E and F). Periodic clinical and radiographic checks were scheduled, and the implants were loaded after 4 months (fig. 3.a G, H and I).

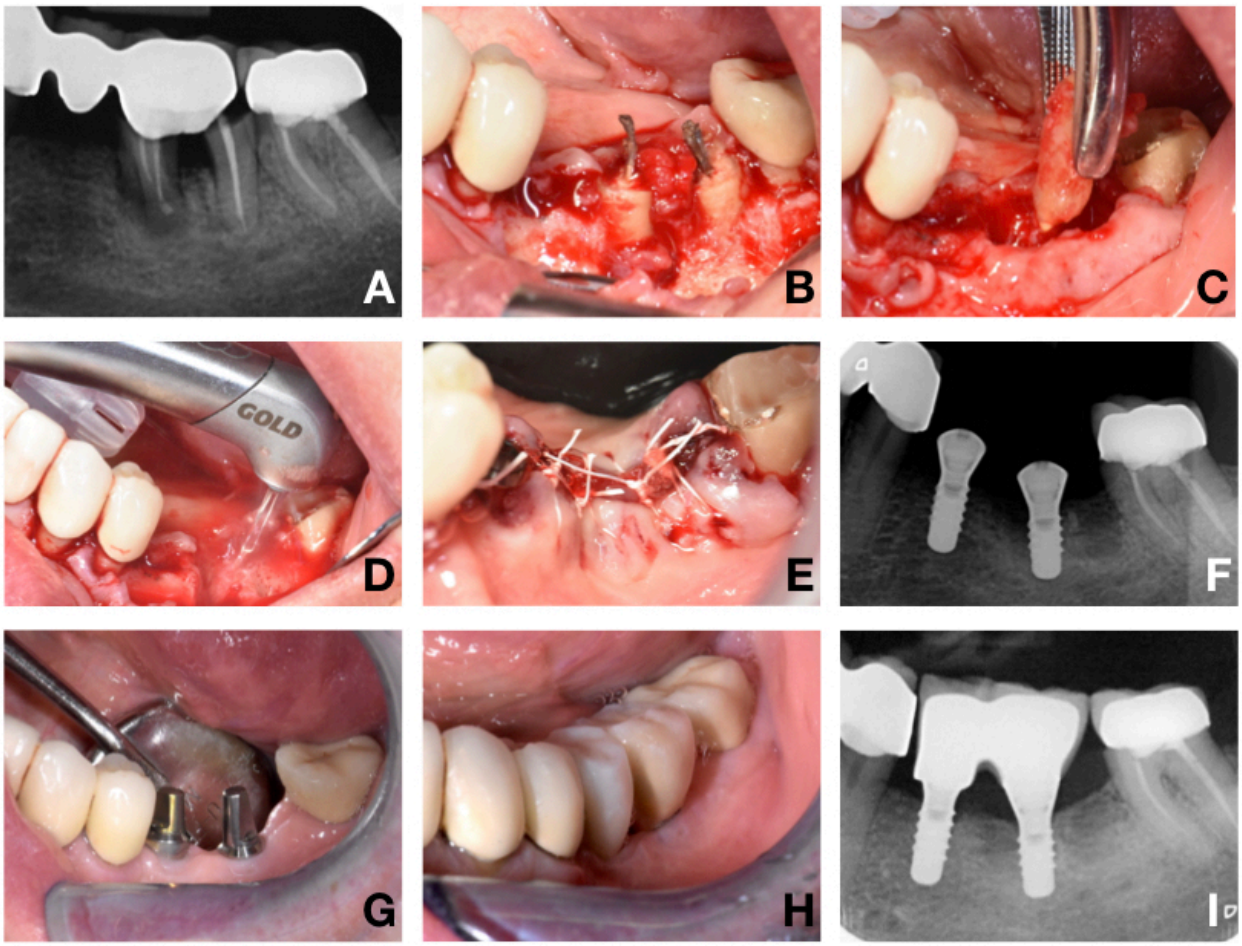


Figure 3.4. A posterior clinical case of the sample.

DISCUSSION

8. DISCUSSION

8a. The difference in MBL and outcome variables in both techniques

From the results, the two groups appear sufficiently homogeneous in terms of age and gender of the patient and areas treated. The variability and, at the same time, the similarity between the two groups make the comparison of this retrospective study more reliable. Surgical options, such as implant length or use of biomaterials, varied according to the clinical situation. Specifically, in the test group the implants were longer: the implant length was greater than about 1 mm in the test group, and the diameter was almost the same. In addition, except for collagen, which had a similar utilization rate in the two groups, membrane and autologous bone were used more often in the test group. This is because in the test group the presence of lesions was greater and therefore bone defects were also treated more often; the scientific literature also shows that the management of the post-extraction socket often requires the use of biomaterials for peri-implant tissue regeneration. [Chrcanovic et al. 2015; Cosyn et al. 2012]. A recent systematic review shows how the bone grafting of the buccal gap simultaneously with immediate implant placement results in preserving hard and soft tissue dimensions; besides, the application of guided bone regeneration techniques aids in soft tissue preservation and prevents resorption of the buccal plate of the immediately placed implant, despite the type of membrane used [AlKudmani et al. 2017].

The main objective was to compare post-extraction implants in infected sites with the traditional technique, where fixtures were placed at least three months after extraction and without signs of residual infections in the alveoli; the results indicate that there is no difference in MBL between two analyzed groups. As a matter of fact the MBL at baseline was 2.4 in both groups ($P = 0.912$). Since it is not always easy to identify the presence of an active infection when it is necessary to remove a

compromised tooth, type 4 implants were chosen for the control group, therefore positioned in edentulous areas with good healing of the post extraction socket. So, in this situation we can be sure that the surgery was performed in an edentulous area free of bacteria.

An X-ray image before placing the implant in the post-extraction site after 12 or 16 weeks of healing allows us to check for the presence of osteolytic lesions. However, recent studies show that even after a suitable period of healing time, bacteria may remain in the bone threatening the implant survival [Flanagan 2016]. The introduction of the laser in implantology therefore not only makes the immediate technique of positioning the fixture safer: laser decontamination could also be useful in the extraction of teeth with lesions to make future implant rehabilitations more predictable even if performed in a deferred manner.

This study analyzed 149 implants in total, with mesial and distal MBL measurements at baseline and follow-up, and it is therefore to date the only controlled study in the literature on implants placement in infected sites decontaminated with the Er,Cr:YSGG 2780 nm laser, according to the authors' knowledge. Furthermore, the present study includes many cases carried out in the posterior sectors, unlike the many immediate implantology studies (type 1) often carried out exclusively in aesthetic areas, where there is less stress than the masticatory load [Meijer & Raghoebar 2020]. In a recent systematic review and meta-analysis, Lee et al. showed the same encouraging conclusion analyzing five prospective studies, that didn’t involve the use of laser but more conventional debridement’s technique; the same authors reported the absence of RCTs on the topic in the literature [Lee et al. 2018]. In a study by Kakar et al., that was recently published, authors followed a clinical protocol similar to the present study including a debridement with Er,Cr:YSGG 2780 nm laser, to treat a case series without control group [Kakar et al. 2020]. However, despite the lack of measurements of the MBL, the interesting data is the survival of the implants which exceeds 95% and is therefore in line with the survival rate that is expected from conventional implantology methods.

Considering the results of the 2017 World Workshop on the classification of periodontal and peri-implant diseases and conditions, to evaluate the success of implant therapy it is important to calculate the MBL, that up to 2 mm can be considered as physiologic bone remodelling [Renvert et al. 2018]. The other factors considered are: visual inspection demonstrating the absence of periimplant signs of inflammation: pink as opposed to red, no swelling as opposed to swollen tissues, firm as opposed to soft tissue consistency; lack of profuse (line or drop) bleeding on probing; probing pocket depths could differ depending on the height of the soft tissue at the implant location. An increase in probing depth over time, however, conflicts with periimplant health.

The data obtained on the MBL in this research is not only in line and lower compared to the control group, but it is also comparable to that of other studies. Among these, Berberi et al. described the MBL in immediate and delayed loading techniques of post-extraction implant [Berberi et al. 2014]; the immediate loading seems to guarantee promising clinical results like the ones showed by several cases in the present study. In fact, as in the present study, also in the work of Barbieri and collaborators, significantly lower MBL associated with immediately loaded implants inserted into fresh extraction sockets was observed when compared to the delayed loading technique. Thus, the suggested hypothesis that greater MBL would be observed in immediately loaded implants was rejected. The rapid and reproducible reformation of peri-implant mucosa within the gingival embrasures can be attributed to minimal MBL, immediate delivery of the interim prostheses, and absence of abutment manipulation during the healing period. Regarding loading and prosthetic phases, this study involved a similar percentage between the test group and the control group of immediate loading cases. This makes the analysis more complete and adds a number of variables which, however, did not influence the clinical and statistical results. Another clinical motivation,

about the difference between MBL in the two groups, may derive from the fact that regenerative techniques are often combined in post-extraction implant situations due to bone defects.

Previous studies, comparing panoramic and periapical radiographs indicated periapical radiographs as the "gold standard" for measuring MBL around dental implants [Kühl et al. 2016; Sirin et al. 2012]. CBCT would also be useful but due to the dose of rays and lack of justification it would not be possible to find a considerable number of patients for the study. The 3D radiographic examination was used only in some cases, as reported in the results, and was also performed for other clinical needs. The need to have comparable radiographs has led to a scrupulous selection of patients in order to increase the reliability of the data. This could be a limitation of the present study. In this context, another limitation of the present study was the relatively small number of implant losses; specifically, due to the small number of implant losses, a random-effects logistic regression analysis was not meaningful and hence, the herein recorded potential predictors could neither be related to early nor to late implant loss. Furthermore, it is a retrospective study, which therefore implies the presence of some bias, although with a protocol already published in previous studies by the same authors [Crippa et al. 2019]. In the present study, only 10 cases had a frank endodontic lesion; it is desirable to undertake prospective studies only on implants placed in sites with endodontic lesions. Finally, another limitation of the study is that, in both groups, antibiotic prophylaxis was administered to the treated patients. This is because even the latest scientific evidence suggests the use of the antibiotic to prevent premature loss of implants. According to the authors of a recent review of the scientific literature, basing on the available RCTs, the use of antibiotic prophylaxis is protective against early implant failures, but there is still insufficient evidence to confidently recommend a specific dosage. The use of post-operative courses does not seem however to be justified by the available literature [Romandini et al. 2019].

8b. Clinical considerations in the use of the laser for immediate implants

The laser (light amplification by stimulated emission of radiation) was introduced into dental practice by Miaman in the 1960s [Verma et al. 2012]. The wavelength of erbium has a high affinity for hydroxyapatite and water. The high affinity for water results in a low penetration depth, which allows good surface ablation without compromising deep tissues. Erbium lasers can cut both soft and hard tissues with minimal thermal damage to the surrounding epithelial tissue, resulting in a low incidence of inflammatory reactions and more rapid healing [Matulić et al. 2019]. The utilization of Er,Cr:YSGG lasers in dentistry has been studied extensively and in several applications. For example, their use adjunctive to conventional periodontal therapy is reported to be effective in bacterial reduction. Additionally, Er,Cr:YSGG lasers are also successful in coagulation of opened blood vessels and deepithelization of the gingival pocket as reported by Dereci et al. [Dereci et al. 2016]. It has also been reported that ER,Cr, and YSGG lasers enhance cell attachment and migration on root surfaces [Hakki et al. 2010]. The Er,Cr:YSGG laser, operating at a wavelength of 2780nm, has been demonstrated to be a valuable tool in endodontic treatment. Martins et al. demonstrated how a laser-assisted protocol can achieve predictable endodontic outcomes, comparable to conventional strategies [Martins et al. 2014]. Therefore, the photoacoustic effect exerted by this type of laser has proven to be effective against many pathogens.

Regardless of the proven laser decontamination effect, several studies have shown that immediate implants can also be placed in infected sites if certain precautions are taken. In a systematic review, Waasdorp et al. affirm that sites must be thoroughly debrided prior to placement and guided bone regeneration is usually performed to fill the bone-implant gap and/or socket deficiencies [Waasdorp et al 2010]. From the point of view of bacterial contamination, this reassures clinicians that the

infected site would not represent an obstacle regardless of the type of decontamination carried out. Certainly, the technique involves a learning curve and requires experience in implantology. There are also some disadvantages, such as the cost of the device. The studies presented by a review on the subject show how immediate placement into infected sites does not lead to an increased rate of complications and does not compromise tissue integration, provided that appropriate clinical procedures are followed to achieve good socket decontamination [Crippa et al. 2020].

The main etiology of periodontitis is plaque accumulation, and the evolution from periodontitis to peri-implantitis occurs in the absence of supportive maintenance care. Periodontal infections are mixed infections caused by different species of aerobic and anaerobic bacteria [Romeo et al. 2004]. Also Dent et al. reported a reduction in implant failures when antibiotics are used pre-operatively [Dent et al. 1997]. Nevertheless, a systematic review suggests that the benefits of antibiotic prophylaxis for non-infected sites are unclear and may not be needed [Esposito et al. 2008; Barone et al. 2017]. It is also important to consider that the presence of some independent systemic (i.e., smoking) and local risk factors (i.e., residual cement, dimensions of the keratinized tissue, and surface roughness) may increase the probability of occurrence of periodontitis [Rabel & Kohler 2006]. In this clinical protocol, the ErCr:YSGG laser was used in association with antibiotics and chlorhexidine gel 0.2%. Therefore, it is not possible to determine a clear causal effect of the laser alone in decontamination and good osseointegration of the implants. For this reason, further clinical studies are needed to clarify certain aspects. In any case, the technique is based on current scientific evidence and on clinical experience that promotes immediate placement of implants, even in infected sites.

In the light of the analysis and studies carried out, the laser offers various advantages both in terms of disinfection, especially in cases of post-extraction implantology, and in terms of tissue healing. The possibility therefore to reduce the patient's discomfort and the operating times, together with the

possibility of performing surgical maneuvers of cutting the flap and disinfection, should push clinicians and researchers to look with greater interest the described technique, which can already count on a lot of scientific literature both as regards the laser and for post-extraction implantology in infected sites, although few articles have been written on combined use.

CONCLUSIONS

9. CONCLUSIONS

The following conclusions can be drawn from the present thesis:

I. The result that there is no difference in MBL, which is even almost better in the test group, seems promising for the clinical application of the described protocol for placement of type 1 implants in infected sites.

II. The complication or failure rate is comparable between the two groups and therefore there is no increased risk in the test group.

REFERENCES

10. REFERENCES

AlKudmani H, Al Jasser R, Andreana S. Is Bone Graft or Guided Bone Regeneration Needed When Placing Immediate Dental Implants? A Systematic Review. Implant Dent. 2017;6:936-944.

Aoki A, Mizutani K, Schwarz F, Sculean A, Yukna RA, Takasaki AA, Romanos GE, Taniguchi Y, Sasaki KM, Zeredo JL, Koshy G, Coluzzi DJ, White JM, Abiko Y, Ishikawa I, Izumi Y. Periodontal and peri-implant wound healing following laser therapy. Periodontol 2000. 2015;1:217-69.

Araújo MG, Lindhe J. Dimensional ridge alterations following tooth extraction. An experimental study in the dog. Journal Clinical Periodontology. 2005;32: 212–218.

Artzi Z, Parson A, Nemcovsky CE. Wide-diameter implant placement and internal sinus membrane elevation in the immediate postextraction phase: clinical and radiographic observations in 12 consecutive molar sites. Int J Oral Maxillofac Implants. 2003;2:242-9.

Ayangco L, Sheridan PJ. Development and treatment of retrograde peri-implantitis involving a site with a history of failed endodontic and apicoectomy procedures: a series of reports. Int J Oral Maxillofac Implants. 2001;16:412-417.

Barone A, Marchionni FS, Cinquini C, Panattoni AC, Toti P, Marconcini S, et al. Antibiotic Treatment to Prevent Postextraction Complications: A Monocentric, Randomized Clinical Trial. Preliminary Outcomes. Minerva Stomatol. 2017;4:148-156.

Berberi AN, Tehini GE, Noujeim ZF, Khairallah AA, Abousehlib MN, Salameh ZA. Influence of surgical and prosthetic techniques on marginal bone loss around titanium implants. Part I: immediate loading in fresh extraction sockets. J Prosthodont. 2014;7:521-7.

Barzilay I, Graser GN, Iranpour B, Proskin HM. Immediate implantation of pure titanium implants into extraction sockets of Macaca fascicularis. Part I: Clinical and radiographic assessment. Int J Oral Maxillofac Implants. 1996;2:3.

Becker W, Becker B, Ricci A, Bahat O, Rosenberg E, Rose L, Handelsman M, Israelson H. A prospective multicenter clinical trial comparing one- and two-stage titanium screw-shaped fixtures with one-stage plasma-sprayed solid-screw fixtures. Clin Implant Dent Relat Res. 2000;3:159-65.

Bell CL, Diehl D, Bell BM, Bell RE. The immediate placement of dental implants into extraction sites with periapical lesions: a retrospective chart review. J Oral Maxillofac Surg. 2011;69:1623-1627.

Bélanger LF. Osteocytic osteolysis. Calcif Tissue Res. 1969;1:1-12.

Block MS, Kent JN. Placement of endosseous implants into tooth extraction sites. J Oral Maxillofac Surg. 1991;12:1269-76.

Bordea IR, Hanna R, Chiniforush N, Grădinaru E, Câmpian RS, Sîrbu A, Amaroli A, Benedicenti S. Evaluation of the outcome of various laser therapy applications in root canal disinfection: A systematic review. Photodiagnosis Photodyn Ther. 2020;29:10-16.

Brisman DL, Brisman AS, Moses MS. Implant failures associated with asymptomatic endodontically treated teeth. J Am Dent Assoc. 2001;132:191-195.

Cafiero C, Annibali S, Gherlone E, Grassi FR, Gualini F, Magliano A, Romeo E, Tonelli P, Lang NP, Salvi GE; ITI Study Group Italia. Immediate transmucosal implant placement in molar extraction sites: a 12-month prospective multicenter cohort study. Clin Oral Implants Res. 2008;19:476-82.

Chang S-W, Shin S-Y, Hong J-R, et al. Immediate implant placement into infected and noninfected extraction sockets: a pilot study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009;107:197-203.

Chang, LC. Implant Periapical Lesion: A Narrative Review. Technologies. 2021;9:65.

Chen ST, Buser D. Clinical and esthetic outcomes of implants placed in postextraction sites. Int J Oral Maxillofac Implants. 2009;24:186-217.

Chen ST, Wilson TG Jr, Hämmerle CH. Immediate or early placement of implants following tooth extraction: review of biologic basis, clinical procedures, and outcomes. Int J Oral Maxillofac Implants. 2004;19:12-25.

Chen H, Zhang G, Weigl P, Gu X. Immediate placement of dental implants into infected versus noninfected sites in the esthetic zone: A systematic review and meta-analysis. J Prosthet Dent. 2018;120:658-667.

Choi AY, Reddy CM, McGary RT, Hill RB, Swenson DT, Seibel P, Hoag JM, Berridge JP, Johnson TM. Adjunctive Nd:YAG Laser Irradiation for Ridge Preservation and Immediate Implant Procedures: A Consecutive Case Series. Clin Adv Periodontics. 2019;9:125-134.

Chrcanovic BR, Martins MD, Wennerberg A. Immediate placement of implants into infected sites: a systematic review. Clin Implant Dent Relat Res. 2015;17:1-16.

Chrcanovic BR, Albrektsson T, Wennerberg A. Dental implants inserted in fresh extraction sockets versus healed sites: a systematic review and meta-analysis. J Dent. 2015;43:16-41.

Corbella S, Taschieri S, Tsesis I, Del Fabbro M. Postextraction implant in sites with endodontic infection as an alternative to endodontic retreatment: a review of literature. J Oral Implantol. 2013;39:399-405.

Cosci F, Cosci B. A 7-year retrospective study of 423 immediate implants. Compend Contin Educ Dent. 1997;18:940-2.

Cosyn J, Vandenbulcke E, Browaeys H, Van Maele G, De Bruyn H. Factors associated with failure of surfacemodified implants up to four years of function. Clinical Implant Dentistry and Related Research. 2012;14:347–58.

Covani U, Cornelini R, Barone A. Bucco-lingual bone remodeling around implants placed into immediate extraction sockets: a case series. J Periodontol. 2003;74:268-73.

Crespi R, Cappare` P, Gherlone E. Immediate loading of dental implants placed in periodontally infected and noninfected sites: a 4-year follow-up clinical study. J Periodontol. 2010;81:1140-1146.

Crespi R, Cappare` P, Gherlone E. Fresh-socket implants in periapical infected sites in humans. J Periodontol 2010;81:378-383.

Crippa R, Aiuto R, Guardincerri M, Peñarrocha Diago M, Angiero F. Effect of Laser Radiation on Infected Sites for the Immediate Placement of Dental Implants. Photobiomodul Photomed Laser Surg. 2020;38:186-192.

Crippa R, Aiuto R, Dioguardi M, Peñarrocha-Diago M, Peñarrocha-Diago M, Angiero F. Laser Therapy for Infected Sites and Immediate Dental Implants in the Esthetic Zone: A Case Report and Review of Literature. Case Rep Dent. 2020;7;2020:23-28.

Dent CD, Olson JW, Farish SE, Bellome J, Casino AJ, Morris HF, et al. The influence of preoperative antibiotics on success of endosseous implants up to and including stage II surgery: a study of 2,641 implants. J Oral Maxillofac Surg. 1997;55:19-24.

Dereci O, Hatipoğlu M, Sindel A, Tozoğlu S, Üstün K. The Efficacy of Er,Cr:YSGG Laser Supported Periodontal Therapy on the Reduction of Peridodontal Disease Related Oral Malodor: A Randomized Clinical Study. Head and Face Medicine. 2016;12:1.

Eger W. Demonstration of calcium and mineralization of bone tissue. Verh Dtsch Ges Pathol. 1963;47:54-69.

Esposito M, Grusovin MG, Talati M, Coulthard P, Oliver R, Worthington HV. Interventions for replacing missing teeth: antibiotics at dental implant placement to prevent complications. Cochrane Database Syst Rev. 2008;3: 41-52.

Esposito M, Hirsch JM, Lekholm U, Thomsen P. Biological factors contributing to failures of osseointegrated oral implants. (I). Success criteria and epidemiology. Eur J Oral Sci. 1998;106:527-51.

Flanagan D. Implant Placement in Failed Endodontic Sites: A Review. J Oral Implantol. 2016;42:224-30.

Friedenstein AJ, Latzinik NV, Gorskaya YuF, Luria EA, Moskvina IL. Bone marrow stromal colony formation requires stimulation by haemopoietic cells. Bone Miner. 1992;18:199-213.

Fugazzotto PA. Success and failure rates of osseointegrated implants in function in regenerated bone for 72 to 133 months. Int J Oral Maxillofac Implants. 2005;20:77-83.

Fugazzotto PA retrospective analysis of immediately placed implants in 418 sites exhibiting periapical pathology: results and clinical considerations. Int J Oral Maxillofac Implants. 2012;27:194-202.

Gelb DA. Immediate implant surgery: three-year retrospective evaluation of 50 consecutive cases. Int J Oral Maxillofac Implants. 1993;8:388-99.

Grunder U, Polizzi G, Goené R, Hatano N, Henry P, Jackson WJ, Kawamura K, Köhler S, Renouard F, Rosenberg R, Triplett G, Werbitt M, Lithner B. A 3-year prospective multicenter follow-up report on the immediate and delayed-immediate placement of implants. Int J Oral Maxillofac Implants. 1999;14:210-6.

Hakki SS, Korkusuz P, Berk G, Dundar N, SaglamM, Bozkurt B, et al. Comparison of Er, Cr:YSGG laser and hand instrumentation on the attachment of periodontal ligament fibroblasts to periodontally diseased root surfaces: an in vitro study. J Periodontol. 2010;81:1216–25.

Hammerle CH, Chen ST, Wilson TG. Consensus statements and recommended clinical procedures regarding the placement of implants in extraction sockets. Int J Oral Maxillofac Implants. 2004;19:26-28.

Hu ML, Zheng G, Lin H, Li N, Zhao PF, Han JM. Network meta-analysis of the treatment efficacy of different lasers for peri-implantitis. Lasers Med Sci. 2021;36:619-629.

Jahangiri L, Devlin H, Ting K, Nishimura I. Current perspectives in residual ridge remodeling and its clinical implications: a review. J Prosthet Dent. 1998;80:224-37.

Jofre J, Valenzuela D, Quintana P, Asenjo-Lobos C. Protocol for immediate implant replacement of infected teeth. Implant Dent. 2012;21:287-94.

Johnson K. A study of the dimensional changes occurring in the maxilla following closed face immediate denture treatment. Aust Dent J. 1969 Dec;14:370-6.

Kakar A, Kakar K, Leventis MD, Jain G. Immediate Implant Placement in Infected Sockets: A Consecutive Cohort Study. J Lasers Med Sci. 2020;11:167-173.

Kan JY, Rungcharassaeng K, Sclar A, Lozada JL. Effects of the facial osseous defect morphology on gingival dynamics after immediate tooth replacement and guided bone regeneration: 1-year results. J Oral Maxillofac Surg. 2007;65:13-9.

Karabuda C, Sandalli P, Yalcin S, Steflik DE, Parr GR. Histologic and histomorphometric comparison of immediately placed hydroxyapatite-coated and titanium plasma-sprayed implants: a pilot study in dogs. Int J Oral Maxillofac Implants. 1999;14:510-5.

Keller U, Hibst R. Effects of Er:YAG laser in caries treatment: A clinical pilot study. Laser Surg Med. 1997;20:32-8.

Koh RU, Rudek I, Wang HL. Immediate implant placement: positives and negatives. Implant Dent. 2010;19:98-108.

Kühl S, Zürcher S, Zitzmann NU, Filippi A, Payer M, Dagassan-Berndt D. Detection of peri-implant bone defects with different radiographic techniques – a human cadaver study. Clin Oral Implants Res. 2016 May;27:529-34.

Kusek ER. Immediate implant placement into infected sites: bacterial studies of the Hydroacoustic effects of the YSGG laser. J Oral Implantol. 2011;37:205-211.

Lin GH, Suárez López Del Amo F, Wang HL. Laser therapy for treatment of peri-implant mucositis and peri-implantitis: An American Academy of Periodontology best evidence review. J Periodontol. 2018;89:766-782.

Lindhe J, Karring T. Clinical periodontology and implant dentistry. Munksgaard 2016; 907.

Linkevicius T, Apse P, Grybauskas S, Puisys A. The influence of soft tissue thickness on crestal bone changes around implants: a 1-year prospective controlled clinical trial. Int J Oral Maxillofac Implants. 2009;24:712-9.

Lee J, Park D, Koo KT, Seol YJ, Lee YM. Comparison of immediate implant placement in infected and non-infected extraction sockets: a systematic review and meta-analysis. Acta Odontol Scand. 2018;76:338-345.

Maggioni M, Scarpelli F, Attanasio T. Il laser in odontoiatria. Piccin nuova libraria 2021; 41.

Marcaccini M, Novaes AJ, Souza S, Taba MJ, Grisi MF. Immediate placement of implants into periodontally infected sites in dogs. Part 2: a fluorescence microscopy study. Int J Oral Maxillofac Implants. 2003;18:812-819.

Marconcini S, Barone A, Gelpi F, Briguglio F, Covani U. Immediate implant placement in infected sites: a case series. Journal of Periodontology. 2013;84:196-202.

Martins M, Carvalho M, Pina-Vaz I, Capelas J, Martins M, Gutknecht N. Outcome of Er,Cr:YSGG laser-assisted treatment of teeth with apical periodontitis: A blind randomized clinical trial. Photomedicine and Laser Surgery. 2014;32:3-9.

Matulić N, Bago I, Sušić M, Gjorgievska E, Kotarac Knežević A, Gabrić D. Comparison of Er:YAG and Er,Cr:YSGG Laser in the Treatment of Oral Leukoplakia Lesions Refractory to the Local Retinoid Therapy. Photobiomodul Photomed Laser Surg. 2019;37:362-368.

Meijer HJA, Raghoebar GM. Immediate implant placement in molar extraction sites: a 1-year prospective case series pilot study. Int J Implant Dent. 2020;6:3.

Montoya-Salazar V, Castillo-Oyagüe R, Torres-Sánchez C, Lynch CD, Gutiérrez-Pérez JL, Torres-Lagares D. Outcome of single immediate implants placed in post-extraction infected and non-infected sites, restored with cemented crowns: a 3-year prospective study. J Dent. 2014;42:645-52.

Nemcovsky CE, Artzi Z. Comparative study of buccal dehiscence defects in immediate, delayed, and late maxillary implant placement with collagen membranes: clinical healing between placement and second-stage surgery. J Periodontol. 2002;73:754-61.

Nevins M, Camelo M, De Paoli S, Friedland B, Schenk RK, Parma-Benfenati S, Simion M, Tinti C, Wagenberg B. A study of the fate of the buccal wall of extraction sockets of teeth with prominent roots. Int J Periodontics Restorative Dent. 2006;26:19-29.

Novaes AJ, Marcaccini A, Souza S, Taba MJ, Grisi MF. Immediate placement of implants into periodontally infected sites in dogs: a histomorphometric study of bone-implant contact. Int J Oral Maxillofac Implants. 2003;18:391-398.

Novaes AJ, Papalexiou V, Grisi M, Souza SS, Taba M Jr, Kajiwara JK. Influence of implant microstructure on the osseointe- gration of immediate implants placed in periodontally infected sites. A histomorphometric study in dogs. Clin Oral Implants Res. 2004;15:34-43.

Paolantonio M, Dolci M, Scarano A, d'Archivio D, di Placido G, Tumini V, et al. Immediate implantation in fresh extraction sockets. A controlled clinical and histological study in man. J Periodontol. 2001;72:1560-1571.

Papalexiou V, Novaes A Jr, Grisi M, Souza SS, Taba M Jr, Kajiwara JK. Influence of implant microstructure on the dynamics of bone healing around immediate implants placed into periodontally infected sites. A confocal laser scanning microscopic study. Clin Oral Implants Res. 2004;15:44–53.

Parker S, Cronshaw M, Anagnostaki E, Mylona V, Lynch E, Grootveld M. Current Concepts of Laser-Oral Tissue Interaction. Dent J. 2020;28:61.

Pinho MN, Roriz VL, Novaes Ab Jr, Taba M Jr, Grisi MF, de Souza SL, Palioto DB. Titanium membranes in prevention of alveolar collapse after tooth extraction. Implant Dent. 2006;15:53-61.

Polizzi G, Grunder U, Goené R, Hatano N, Henry P, Jackson WJ, Kawamura K, Renouard F, Rosenberg R, Triplett G, Werbitt M, Lithner B. Immediate and delayed implant placement into extraction sockets: a 5-year report. Clin Implant Dent Relat Res. 2000;2:93-9.

Rabel A, Kohler SG. Microbiological study on the prognosis of immediate implant and periodontal disease. Mund Kiefer Gesichtschir. 2006;10:7-13.

Renvert S, Persson GR, Pirih FQ, Camargo PM. Peri-implant health, peri-implant mucositis, and peri-implantitis: Case definitions and diagnostic considerations. J Periodontol. 2018;89:304-312.

Romandini M, De Tullio I, Congedi F, Kalemaj Z, D'Ambrosio M, Laforí A, Quaranta C, Buti J, Perfetti G. Antibiotic prophylaxis at dental implant placement: Which is the best protocol? A systematic review and network meta-analysis. J Clin Periodontol. 2019;46:382-395.

Romanos G. Current concep! ts in the use of lasers in periodontal and implant dentistry. J Indian Soc Periodontol. 2015;19:490-4.

Romanos GE, Gupta B, Yunker M, Romanos EB, Malmstrom H. Lasers use in dental implantology. Implant Dent. 2013;22:282-8.

Romeo E, Ghisolfi M, Carmagnola D. Peri-implant Diseases. A Systematic Review of the Literature. Minerva Stomatol. 2004;53:215-30.

Rosenquist B, Ahmed M. The immediate replacement of teeth by dental implants using homologous bone membranes to seal the sockets: clinical and radiographic findings. Clin Oral Implants Res. 2000;11:572-82.

Rosenquist B, Grenthe B. Immediate placement of implants into extraction sockets: implant survival. Int J Oral Maxillofac Implants. 1996;11:205-9.

Sanz M, Cecchinato D, Ferrus J, Pjetursson EB, Lang NP, Lindhe J. A prospective, randomized-controlled clinical trial to evaluate bone preservation using implants with different geometry placed into extraction sockets in the maxilla. Clin Oral Implants Res. 2010;21:13-21.

Schropp L, Kostopoulos L, Wenzel A. Bone healing following immediate versus delayed placement of titanium implants into extraction sockets: a prospective clinical study. Int J Oral Maxillofac Implants. 2003;18:189-99.

Schulte W, Heimke G. The Tubinger immediate implant. Quintessenz. 1976;27:17-23.

Schulte W, Kleineikenscheidt H, Lindner K, Schareyka R. The Tübingen immediate implant in clinical studies. Dtsch Zahnarztl Z. 1978;33:348-59.

Schwartz-Arad D, Chaushu G. The ways and wherefores of immediate placement of implants into fresh extraction sites: a literature review. J Periodontol. 1997;68:915-923.

Schroeder HE. The periodontium. Handbook of Microscopic Anatomy. Springer 1986; 233-246.

Siqueira JF Jr, Rijas IN, Oliveria JC, Santos KR. Molecular detection of black-pigmented bacteria in infections of endodontic origin. J Endod. 200;27:563-566.

Sirin Y, Horasan S, Yaman D, Basegmez C, Tanyel C, Aral A, Guven K. Detection of crestal radiolucencies around dental implants: An in vitro experimental study. J Oral Maxillofac Surg. 2012;70:1540-50.

Soldatos N, Romanos GE, Michaiel M, Sajadi A, Angelov N, Weltman R. Management of Retrograde Peri-Implantitis Using an Air-Abrasive Device, Er,Cr:YSGG Laser, and Guided Bone Regeneration. Case Rep Dent. 2018;15:32-40.

Trombelli L, Farina R, Marzola A, Bozzi L, Liljenberg B, Lindhe J. Modeling and remodeling of human extraction sockets. J Clin Periodontol. 2008;35:630-9.

Urist MR. Bone: formation by autoinduction. Science. 1965;150:893-9.

Vanden Bogaerde L, Rangert B, Wendelhag I. Immediate/early function of Brånemark System TiUnite implants in fresh extraction sockets in maxillae and posterior mandibles: an 18 month prospective clinical study. Clin Implant Dent Relat Res. 2005;1:121-30.

Van der Weijden F, Dell'Acqua F, Slot DE. Alveolar bone dimensional changes of post-extraction sockets in humans: a systematic review. J Clin Periodontol. 2009;36:1048-58.

Verma SK, Maheshwari S, Singh RK, Chaudhari PK. Laser in dentistry: An innovative tool in modern dental practice. Natl J Maxillofac Surg. 2012;3:124-32.

Walsh LJ. Laser dentistry: membrane-based photoacoustic and biostimulatory applications in clinical practice. Australasian Dental Practice. 2006;17:62-64.

Waasdorp JA, Evian CI, Mandracchia M. Immediate placement of implants into infected sites: a systematic review of the literature. Journal of Periodontology. 2010;81:801-808.

Wegner RN. Mastication pressure and alveolar changes. Anat Anz. 1964;114:1-26.

Werbitt MJ, Goldberg PV. The immediate implant: bone preservation and bone regeneration. Int J Periodontics Restorative Dent. 1992;12:206-217.

Woodruff LD, Bounkeo JM, Brannon WM, Dawes KS, Barham CD, Waddell DL, Enwemeka CS. The efficacy of laser therapy in wound repair: a meta-analysis of the literature. Photomed Laser Surg. 2004;22:241-7.

Zuffetti F, Capelli M, Galli F, Del Fabbro M, Testori T. Post-extraction implant placement into infected versus non-infected sites: A multicenter retrospective clinical study. Clin Implant Dent Relat Res. 2017;19:833-840.

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SCIENTIFIC PUBLICATIONS

12. SCIENTIFIC PUBLICATIONS DERIVED FROM THE PRESENT THESIS

- Crippa R, **Aiuto R**, Guardincerri M, Peñarrocha Diago M, Angiero F. Effect of Laser Radiation on Infected Sites for the Immediate Placement of Dental Implants. Photobiomodul Photomed Laser Surg. 2020 Mar;38(3):186-192. doi: 10.1089/photob.2019.4636. Epub 2019 Sep 19. PMID: 31429669.

- Crippa R, **Aiuto R**, Dioguardi M, Peñarrocha-Diago M, Peñarrocha-Diago M, Angiero F. Laser Therapy for Infected Sites and Immediate Dental Implants in the Esthetic Zone: A Case Report and Review of Literature. Case Rep Dent. 2020 Jan 7;2020:2328398. doi: 10.1155/2020/2328398. PMID: 31970001; PMCID: PMC6973183.

- **Aiuto R**, Angiero F, Peñarrocha Diago M, Peñarrocha Diago M, Crippa R. Impianti postestrattivi inseriti in siti infetti decontaminati con il laser: studio di coorte retrospettivo. CDUO Milano 2020 (**Winner poster in the laser section**).

- **Aiuto R**, Dioguardi M, Angiero F, Peñarrocha-Diago M, Peñarrocha-Diago M, Crippa R. Clinical procedures for immediate dental implant placement in post-extraction-infected sites decontaminated with Er,Cr:YSGG laser. Italian Journal of Dental Medicine. Issue 2, vol. 6; 2021.

- De Michele S, **Aiuto R**, Peñarrocha-Diago M, Peñarrocha-Diago M, Angiero F, Crippa R. Impianti immediati post-estrattivi in siti infetti con ausilio del laser Er,Cr: YSGG (2.780nm). Il Dentista Moderno. Anno XXXIX, n.11/2021.

- Crippa R, **Aiuto R**, Dioguardi M, Nieri M, Peñarrocha-Diago M, Peñarrocha-Diago M, Angiero F. Immediate dental implant placement in post-extraction-infected sites decontaminated with Er,Cr:YSGG laser: a retrospective cohort study. ODON-D-21-00635 (Accepted for publication - Odontology).

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Case Reports

Effect of Laser Radiation on Infected Sites for the Immediate Placement of Dental Implants

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Abstract

Objective: The study aims to evaluate the feasibility of erbium-chromium: yttrium-scandium-gallium-garnet (ErCr:YSGG 2780 nm) laser irradiation on infected and/or inflamed post-extraction sites for the immediate placement, and when possible, immediate loading, of endosseous implants.
Background: Post-extraction site infection is a serious complication. Surgical and nonsurgical options are available to treat such event, together with various decontamination methods. However, there is still no consensus on which treatment is the most effective.
Materials and methods: Sixty-six patients were included in the study for a total of 94 post-extraction implants, inserted in the maxilla and mandible. All patients were eligible for implant therapy, having at least one compromised tooth requiring extraction, along with sign of inflammation and/or infection. Surgery and socket decontamination were performed using an ErCr:YSGG laser. To improve bone healing, Bio-Oss® and resorbable membrane were used in 57 patients. Eleven implants were immediately loaded, whereas 83 were loaded within 3–6 months, depending on the extraction site. Intraoral radiographs were taken at 1, 3, 6, 9, and 12 months from the implant placement to assess the alveolar bone level and treatment's outcome.
Albrektsson criteria were chosen to evaluate the treatment success rate.
Results: Follow-up went from 6 months to 4 years. Success rate was 94.6% (89/94): three implants failed to integrate due to poor patient compliance, being expelled during the second week, whereas two implants presented factory defects (abutment). No sockets presented signs of residual infection during follow-up.
Conclusions: The combination of mechanical, chemical, and laser treatment was proven to be highly effective for the disinfection of post-extraction sites. The ErCr:YSGG laser is a useful tool, not only for his practicality as a surgical device but also as a disinfection tool, granting optimal results after implant surgery.

Keywords: Er,Cr:YSGG laser, laser therapy, immediate implant placement, post-extraction infected alveoli

Introduction

TO HAVE ENOUGH TIME for the socket to heal, clinicians traditionally waited several months after tooth extraction, before inserting dental implants.[1,2] In 1976, Schulte and Heimke introduced the concept of immediate implant placing. Anneroth et al. published the first study with an animal model. Later on, in 1989, Lazzara reported one case of immediate implant placement in an extraction socket in humans.[3]

Today, immediate implant placement in post-extraction sockets is a common practice and several studies have shown this procedure to have a high success rate; it reduces alveolar bone loss and the ridge bone morphological changes resulting from tooth extraction, as well as reducing treatment time and costs, and preserving esthetic.[4–6] The social and economic features of this technique make it advantageous when greater bone crest volumes for esthetic and functional reasons are needed and bone grafting is advisable.[7,8] Further, the number of surgical procedures and treatment time can be both minimized, increasing patient satisfaction. The immediate loading of such implants has also been proposed, and positive results are reported.[9,10] Some authors recommend avoiding the placement of implants in fresh sockets showing signs of

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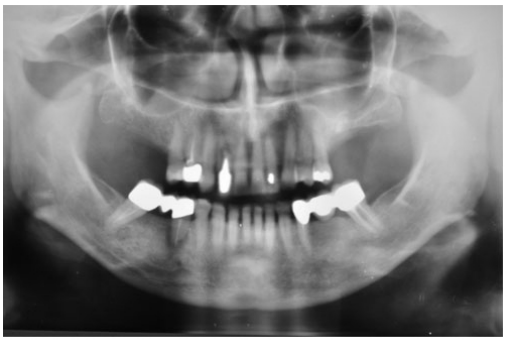

FIG. 1. Pre-operative orthopantomography.

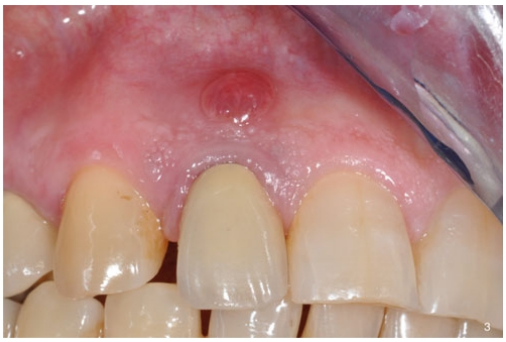

FIG. 3. Pre-operative clinical image.

infection.[11,12] Nevertheless, several studies report high success rate for immediately placed and, in some cases, for immediately loaded implants in infected or inflamed post-extraction sites.[13–17] Measures to decrease the bacterial load of infected sites include meticulous cleaning, alveolar debridement, the administrations of antibiotics, and post-operative Chlorhexidine 0.12% mouth rinses.[18–20] Assuming these clinical procedures and socket decontamination techniques are employed, the presence of an infection or periradicular, periapical, endodontic, or carious lesions appears not to compromise implant survival rate.[21,22] The same holds for the presence of root fractures or root resorption.[23]

Recent studies have highlighted that the laser technology is capable of eliminating bacteria more effectively then chemical products (1000 vs. 100 μm).[24] This study aims to report a case series of implant therapy by utilizing the erbium-chromium: yttrium-scandium-gallium-garnet (ErCr:YSSG) laser energy for decontamination of post-extraction infected sockets.

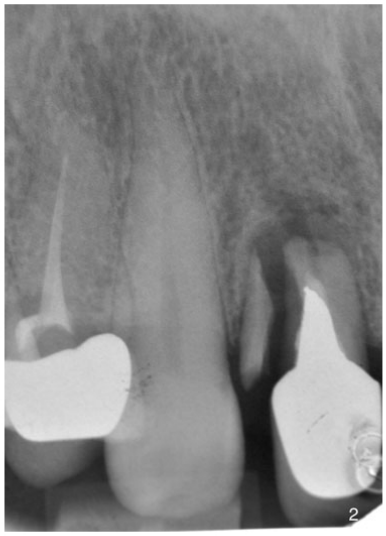

FIG. 2. Pre-operative periapical radiograph.

Materials and Methods

All patients eligible for implant treatment, having at least one compromised tooth presenting clinical or radiological signs of infection (Figs. 1–3), either periapical/endodontic, periodontic and/or periodontal, were included in the study between January 2013 and December 2016. Mandibular and maxillary sites were included.

Exclusion criteria were immune-suppressed or immune-compromised patients, uncontrolled diabetes, pregnancy or lactation, untreated periodontal disease, and history of treatment or ongoing treatment with aminobiphosphonates.

Ortocain (1:100,000) was used as an anesthetic, and after the flap (Fig. 4) using ErCr:YSGG 2780 nm laser device I-PLUS Handpiece GOLD (Biolase Technology) 3.0 W, 50 Hz (SOFT TISSUE Tip: MC-3, length 9 mm, AIR 20%, WATER 40%; HARD TISSUE Tip: MZ-8, length 9 mm, AIR 40%, WATER 60%, 3.5 W, 60 Hz), and tooth pliers, teeth were extracted. Extraction sites were then debrided and decontaminated (Fig. 5) with the same laser device (2.0 W, 15 Hz, 40% Air, 60% Water, 100 mL H_2O/min in hard tissue mode) mounting a MZ-6, length 9 mm tip (Table 1). Debridement time depended on the amount of pathologic tissue and bone volume, whereas

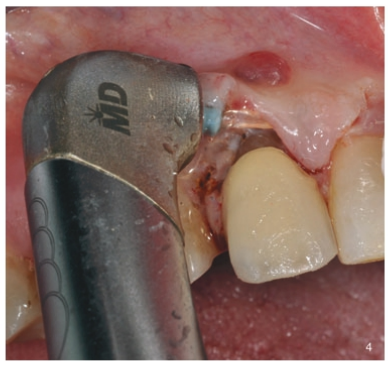

FIG. 4. Opening of a trapezoidal flap using the Er-Cr:YSGG laser device. ErCr:YSGG, erbium-chromium: yttrium-scandium-gallium-garnet.

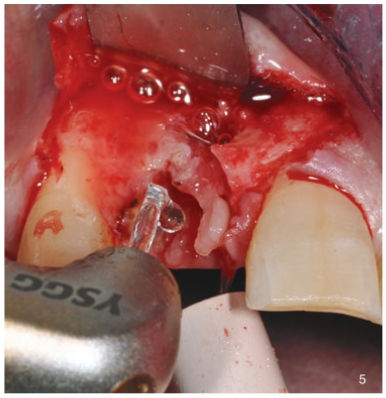

FIG. 5. Socket's debridement and disinfection.

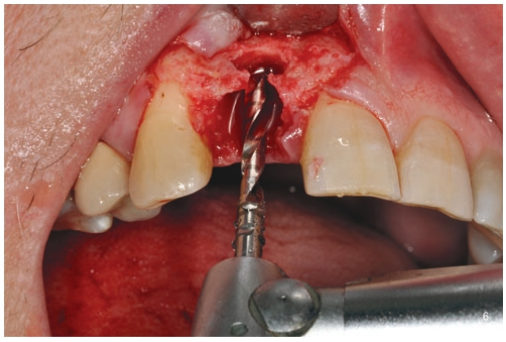

FIG. 6. Implant site preparation.

decontamination lasted from 60 to 90 sec per socket, with the tip not in contact with the tissues. Straumann® Dental Implant System (tissue level type) and Evolution® Implant System were used for the implant surgery (Fig. 6). The materials used in graft cases are Guidor matrix-barrier (DeOre Materials®) and Geistlich Bio-Oss® (Geistlich Biomaterials®) (Fig. 7). The suturing material used was PTFE Omnia 3/0, 19 mm 3/8 (Fig. 8).

Albrektsson criteria were chosen to evaluate the treatment success rate.[2] An implant was considered successful when

- –No mobility was present at clinical test
- –No peri-implant radiolucency was evidenciated in all radiographic checkups
- –Bone loss inferior than 0.2 mm annually after the first year
- –No persistent pain, discomfort, or infection
- –The width of the attached gingiva was >2 mm.

A post-operatory radiograph was taken, and antibiotic therapy was prescribed together with Broxodin gel (chlorhexidine gluconate 0.20%) manufactured by Specialita' Igienico Terapeutiche (SIT) (twice daily for 15–20 days). A radiologic checkup was scheduled at 1, 3, 6, 9, and 12 months after surgery. For immediately loaded implants in the frontal region, Maryland bridges were used as temporary restoration (Fig. 9); they were positioned just after suture removal ($\sim$15 days after surgery) or 3 weeks later (depending on site healing). The bridge wings were either fixed or removable, the latter being preferred to allow correct hygiene procedures. Temporary protective coping was used with the bridges to give them more stability, while removable temporary winged restorations were utilized for the posterior region. For implants not scheduled for immediate loading, submerged healing was preferred; the above laser device was then used to reopen the site. For those implants not immediately loaded, time to loading ranged from 3 to 5 months, depending on implant location, bone healing, and patient compliance (Figs. 10 and 11). A week after the surgery, patients were asked to assign a numeric value to post-operative pain on a verbal numeric scale (VNS) ranging from 0 to 10.

Results

Sixty-six patients were enrolled in the study. The majority of patients were nonsmokers (80%); 13 patients (20%) had diabetes.

A total of 94 teeth were extracted: 50 presented root fracture (of which 5 with fistula), 17 abscess, 17 endodontic and/or periodontic disease, and 10 carious lesions (Table 2). Ninety-four implants were placed in infected extraction sites after debridement and decontamination with the ErCr:YSGG laser. None presented post-surgical complications due to infection. A total of 93 Straumann implants (31T.E.—35 Standard—27 Standard Plus) and 1 Evolution 2000 were inserted. All implants were inserted with a minimum torque value of 35N, 1 mm below the most apical bone peak, and four of them have been immediately loaded. To improve bone healing, Bio-Oss® and a resorbable membrane were used in 57 patients (Geistlich® Bio-Oss Collagen 100 mg and Geislich® Bio-Gide 16×22 mm), while 9 patients did not require bone augmentation.

TABLE 1. LASER BIOLASE I-PLUS 2780 NM (BIOLASE TECHNOLOGY)

Modality	*Soft tissue (flap)*	*Hard tissue*	*Decontamination*
Handpiece	Gold	Gold	Gold
Power	3.0 W in SP mode	3.5 W in SP mode	2.0 W in SP mode
Frequency	50 Hz	60 Hz	15 Hz
Tip	MC-3, length 9 mm, width 300–1200 μm	MZ-8, length 9 mm, width 800 μm	MZ-6, length 9 mm, width 600 μm
Water	40%	60%	60% (100 mL/min)
Air	20%	40%	40%

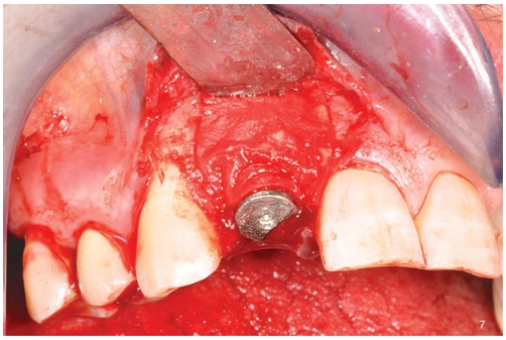

FIG. 7. Implant after bio-oss and membrane placement.

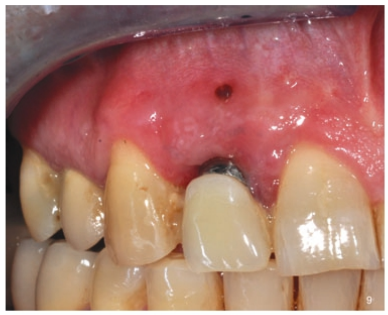

FIG. 9. Provisional Maryland Bridge.

Three implants were lost in the first 2 weeks after surgery. The implant manufacturer Straumann accepted there were factory defects in one lot, for which reason, two implants had to be replaced, although no problems with osseointegration has been observed. Of the remaining 89 implants, the success rate was 100% for the procedure described. The same holds from the standpoint of prosthetic success: none of the implants (either immediately or delayed loading) failed for prosthetic reasons. The overall success rate for implant positioning was 94.6% (89/94).

Table 3 describes the VNP score given by the patients 1 week after implant loading. Some 90% of patients assigned a score <6 (Table 3).

Radiographic checkups showed excellent results (Fig. 12) with guided bone regeneration. A good osseointegration had been achieved for all implants, except the three who failed, with no radiologically evident loss of crestal bone height, except for the amount normally expected (<0.2 mm every year after the first one), despite some patients having missed some checkup appointments.

Discussion

This study shows how immediate placement into infected sites does not lead to an increased rate of complications, nor compromises tissue integration, provided that appropriate clinical procedures are followed to achieve good socket decontamination. The high success rate reported appears to justify the use of laser devices to obtain good socket disinfection. Thirteen patients (20%) received prophylactic antibiotic therapy the day before surgery.

The main etiology of periodontitis refers to plaque accumulation and the evolution from periodontitis to peri-implantitis occurs in the absence of a supportive maintenance care. Periodontal infections are mixed infections caused by different species of aerobic and anaerobic bacteria. Dent and colleagues report a reduction in implant failures when antibiotics are used pre-operatively.[25] Nevertheless, a systematic review suggests that the benefits of antibiotic prophylaxis for not infected sites are unclear and may not be needed.[26]

Bacteroides species, such as Bacteroides forsythus, may survive in an encapsulated form in bone tissue after tooth extraction and subsequently infect an implant.[27] It appears that even after vigorous debridement and irrigation of the sockets, bacteria may remain in the bone, and this could lead to retrograde peri-implantitis.[28] Retrograde peri-implantitis is indicated by radiolucencies around the most apical part of an osseointegrated implant; the condition can be caused by the remaining scar or granulomatous tissue after immediate implant placement into extraction sockets.[29] Conversely, studies on animal models have shown that implants placed in artificially induced periapical lesions achieved osseointegration as successfully as implants placed at healthy sites.[30–32] Moreover, studies on humans confirm that there is no significant

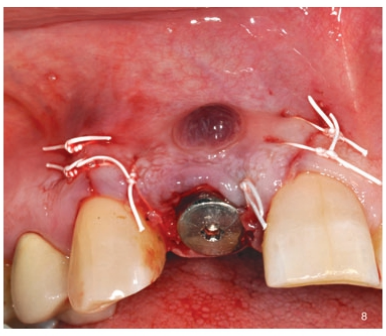

FIG. 8. Suture.

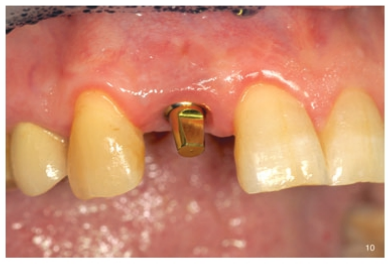

FIG. 10. Prosthodontic phase after 3 months.

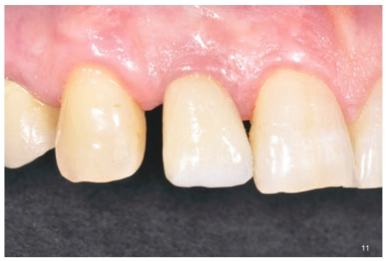

FIG. 11. Definitive prosthesis.

Table 3. Verbal Numeric Scale Score

VNS score	*Number of patients*
0	6
1	16
2	15
3	13
4	6
5	3
6	5
7	1
8	1

VNS, verbal numeric scale.

difference in implant prognosis between those placed in healthy and infected post-extraction sockets.[33]

The presence of some independent systemic (i.e., smoking) and local risk (i.e., residual cement, dimensions of the keratinized tissue, and surface roughness) factors may increase the probability of the periodontitis disease occurring. In particular, smoking is a known modifying factor in risk assessment for implant surgery. In a study investigating the prevalence of periodontal disease marker organism and specific interleukin-1 gene polymorphism (closely related to periodontism), and their effect on the success of immediate implant placement after extraction in patients with periodontal disease, Rabel and Kohler report that smoking increases the risk of implant failure in a statistically significant manner.[34] This could be related to the fact that two of the three patients who lost an implant in this study were actually smokers.

Several alternative or adjunctive measures (local antibiotics, air polishing, and laser application) have been proposed and there is still a need to identify the most effective interventions for the treatment of peri-implant disease.[35,36] The bactericidal efficacy of laser devices in oral infections has been confirmed by previous studies; *in vitro* experiments show the laser capability of reducing the bacterial count and CFU (colony-forming units) number.[37–39] To obtain a good disinfection power, settings and time of treatment are very important factors to be considered. In fact, higher power allows for more bacteria to be killed, but at the same time, the collateral damage to the tissue is increased; by extending treatment time, it is possible to achieve a good effect, keeping a low power setting, without harming the tissue; thus, a balance between these factors has to be found. Given the different laser devices available on the market for this kind of procedure (diode laser, Er:Cr, Er:YAG, and Neodymium:YAG) and the vast amount of settings, a standard and reliable protocol have yet to be described. Moreover, the operator experience with this kind of technique plays a fundamental role. In this particular study, an ErCr:YSGG laser was used in association with antibiotics and other means, such as chlorhexidine rinses, and it is thus not possible to determine a clear causal effect of the laser alone in decontamination and ensure good osseointegration of the implants. Nevertheless, using a laser device for implant surgery can be really helpful in reducing intraoperative bleeding and thus in keeping the operative field clear.[40]

Considering the VNS score we used to evaluate post-operative pain, we indeed noticed an average score of 2.5 out of 10, with 90% of the patients assigning a score <6. This could be due to the laser intrinsic characteristic of reducing post-operative inflammation, as several studies have shown how laser devices are capable to considerably reduce post-

Table 2. Patients Involved in the Study

	n = *66*
Age (mean ± SD)	58.454545454545 ± 9.607980365992)
Reason for extraction	
Fracture	43
Carious lesion	11
Periodontal disease	23
Abscess	6
Endodontic lesion	11
Bone augmentation	
Yes	77
No	17
Type of loading	
Immediate	12
Delayed	82
Failures	3

SD, standard deviation.

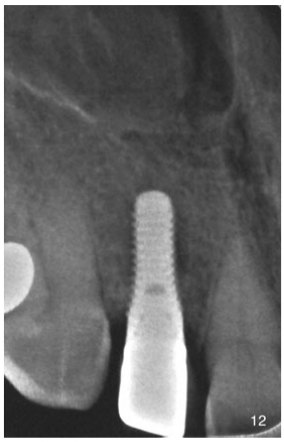

FIG. 12. One-year follow-up periapical radiograph.

operative pain and swelling.[41] A limitation to this work is due to the absence of a control group. However, the authors referred to previously published series to describe and compare the effectiveness of laser energy for implant loading.

Conclusions

Immediate implant placement in infected post-extraction sockets does not seem to increase failure risk, provided that certain clinical procedures are followed. Within the limits of this study, decontamination and debridement of an infected socket using an ErCr:YSGG laser device is an effective and practical tool to prevent retrograde peri-implantitis and infective complications, when placing immediate post-extractive implants. Further studies are needed to investigate a precise role for laser irradiation in this connection.

Author Disclosure Statement

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References

1. Adell R, Lekholm U, Rockler B, Branemark PI. A 15-year study of osseointegrated implants in the treatment of the edentulous jaw. Int J Oral Surg 1981;10:387–416.
2. Albrektsson T, Zarb G, Worthington P, Eriksson AR. The long-term efficacy of currently used dental implants: a review and proposed criteria of success. Int J Oral Maxillofac Implants 1986;1:11–25.
3. Lindeboom JA, Tjiook Y, Kroon FH. Immediate placement of implants in periapical infected sites: a prospective randomized study in 50 patients. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006;101:705–710.
4. Carlsson GE, Persson G. Morphologic changes of the mandible after extraction and wearing of the denture. Odontol Rev 1967;18:27–54.
5. Atwood D. Post extraction changes in the adult mandible as illustrated by microradiographs of midsagittal section and serial cephalometric roentgenograms. Prosthet Dent 1963; 13:810–816.
6. Schropp L, Wenzel A, Kostopoulos L, Karring T. Bone healing and soft tissue contour changes followin single-tooth extraction: a clinical and radiographic 12-month prospective study. Int J Periodontics Restorative Dent 2003;23:313–323.
7. Casap N, Zeltser C, Wexler A, Tarazi E, Zeltser R. Immediate placement of dental implants into debrided infected dentoalveolar sockets. J Oral Maxillofac Surg 2007;65:384–392.
8. Rosenquist B, Grenthe B. Immediate placement of implants into extraction sockets: implant survival. Int J Oral Maxillofac Implants 1996;11:205–209.
9. Quirynen M, Gijbels F, Jacobs R. An infected jawbone site compromising successful osseointegration. Periodontol 2000 2003;33:129–144.
10. Werbitt MJ, Goldberg PV. The immediate implant: bone preservation and bone regeneration. Int J Periodontics Restorative Dent 1992;12:206–217.
11. Becker W, Becker BE. Guided tissue regeneration for implants placed into extraction sockets and for implant dehiscences: surgical techniques and case report. Int J Periodontics Restorative Dent 1990;10:376–391.
12. Barzilay I. Immediate implants: their current status. Int J Prosthodont 1993;6:169–175.
13. Pecora G, Andreana S, Covani U, De Leonardis D, Schifferle RE. New directions in surgical endodontics; immediate implantation into an extraction site. J Endod 1996;22: 135–139.
14. Villa R, Rangert B. Early loading of interforaminal implants immediately installed after extraction of teeth presenting endodontic and periodontal lesions. Clin Implant Dent Relat Res 2005;7 (Suppl. 1):S28–S35.
15. Siegenthaler DW, Jung RE, Holderegger C, Roos M, Hammerle CH. Replacement of teeth exhibiting periapical pathology by immediate implants: a prospective, controlled clinical trial. Clin Oral Implants Res 2007;18:727–737.
16. Villa R, Rangert B. Immediate and early function of implants placed in extraction sockets of maxillary infected teeth. A pilot study. J Prosthet Dent 2007;97:S96–S108.
17. Crespi R, Capparè P, Gherlone E. Immediate loading of dental implants placed in periodontally infected and non-infected sites: a 4-year follow-up clinical study. J Periodontol 2010;81:1140–1146.
18. Crespi R, Capparè P, Gherlone E. Fresh-socket implants in periapical infected sites in humans. J Periodontol 2010;81: 378–383.
19. Bell CL, Diehl D, Bell BM, Bell RE. The immediate placement of dental implants into extraction sites with periapical lesions: a retrospective chart review. J Oral Maxillofac Surg 2011;69:1623–1627.
20. Fugazzotto P. A retrospective analysis of immediately placed implants in 418 sites exhibiting periapical pathology: results and clinical considerations. Int J Oral Maxillofac Implants 2012;27:194–202.
21. Jofre J, Valenzuela D, Quintana P, Asenjo-Lobos C. Protocol for immediate implant replacement of infected teeth. Implant Dent 2012;21:287–294.
22. Marconcini S, Barone A, Gelpi F, Briguglio F, Covani U. Immediate implant placement in infected sites: a case series. J Periodontol 2013;84:196–202.
23. Chrcanovic BR, Martins MD, Wennerberg A. Immediate placement of implants into infected sites: a systematic review. Clin Implant Dent Relat Res 17 Suppl 2015;1:e1–e16.
24. Kusek ER. Immediate implant placement into infected sites: bacterial studies of the Hydroacoustic effects of the YSGG laser. J Oral Implantol 2011;37:205–211.
25. Dent CD, Olson JW, Farish SE, Bellome J, Casino AJ, Morris HF, Ochi S. The influence of preoperative antibiotics on success of endosseous implants up to and including stage II surgery: a study of 2,641 implants. J Oral Maxillofac Surg 1997;55(12 Suppl 5):19–24.
26. Esposito M, Grusovin MG, Talati M, Coulthard P, Oliver R, Worthington HV. Interventions for replacing missing teeth: antibiotics at dental implant placement to prevent complications. Cochrane Database Syst Rev 2008;3:CD004152.
27. Siqueira JF Jr., Rijas IN, Oliveria JC, Santos KR. Molecular detection of black-pigmented bacteria in infections of endodontic origin. J Endod 2001;27:563–566.
28. Ayangco L, Sheridan PJ. Development and treatment of retrograde peri-implantitis involving a site with a history of failed endodontic and apicoectomy procedures: a series of reports. Int J Oral Maxillofac Implants 2001;16:412–417.
29. Quirynen M, Vogels R, Alsaadi G, Naert I, Jacobs R, van Steenberghe D. Predisposing conditions for retrograde peri-

implantitis, and treatment suggestions. Clin Oral Implants Res 2005;16:599–608.
30. Marcaccini AM, Novaes AB Jr., Souza SL, Taba M Jr., Grisi MF. Immediate placement of implants into periodontally infected sites in dogs. Part 2: a fluorescence microscopy study. Int J Oral Maxillofac Implants 2003;18:812–819.
31. Novaes AB Jr., Marcaccini AM, Souza SLS, Taba M Jr., Grisi MFM. Immediate placement of implants into periodontally infected sites in dogs: a histomorphometric study of bone-implant contact. Int J Oral Maxillofac Implants 2003;18:391–398.
32. Papalexiou V, Novaes AB Jr., Grisi MF, Souza SS, Taba M Jr., Kajiwara JK. Influence of implant microstructure on the dynamics of bone healing around immediate implants placed into periodontally infected sites. A confocal laser scanning microscopic study. Clin Oral Implants Res 2004;15:44–53.
33. Fugazzotto PA. A retrospective analysis of implants immediately placed in sites with and without periapical pathology in sixty-four patients. J Periodontol 2012;83:182–186.
34. Rabel A, Köhler SG. Microbiological study on the prognosis of immediate implant and periodontal disease. Mund Kiefer Gesichtschir 2006;10:7–13.
35. Aung N, Aoki A, Takeuchi Y. The effects of ultraviolet light-emitting diodes with different wavelengths on periodontopathic vacteria in vitro. Photobiomodul Photomed Laser Surg 2019;37:288–297.
36. Shibli JA. Is laser the best choice for the treatment of peri-implantitis? Photomed Laser Surg 2018;36:569–570.
37. Licata ME, Albanese A, Campisi G, Geraci DM, Russo R, Gallina G. Effectiveness of a new method of disinfecting the root canal, using Er, Cr:YSGG laser to kill Enterococcus faecalis in an infected tooth model. Lasers Med Sci 2015;30:707–712.
38. Goncalves F, Zanetti AL, Zanetti RV, Granjeiro JM. Effectiveness of 980-mm diode and 1064-nm extra-long-pulse neodymium-doped yttrium aluminum garnet lasers in implant disinfection. Photomed Laser Surg 2010;28:273–280.
39. Mailoa J, Lin GH, Chan HL, Wang HL. Clinical outcomes of using lasers for peri-implantitis surface detoxification: a systematic review and meta-analysis. J Periodontol 2014;85:1194–1202.
40. Chrcanovic BR, Martins MD, Wenneberg A. Immediate placement of implants into infected sites: a systematic review. Wiley Periodicals, Inc 2013. Clin Implant Dent Relat Res 2015;17 Suppl 1:e1–e16.
41. Ritter PL, González VM, Laurent DD, Lorig KR. Measurement of pain using the visual numeric scale. J Rheumatol 2006;33:574–580.

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Case Report

Laser Therapy for Infected Sites and Immediate Dental Implants in the Esthetic Zone: A Case Report and Review of Literature

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Placement of postextraction dental implants has become a common practice. Here, we reviewed current literature, along with clinical procedures, outcomes, and incidence of complications, associated with immediate implants in infected postextraction sites. The YSGG (yttrium, scandium, gallium, and garnet) laser can significantly reduce the bacterial concentration after extracting a compromised tooth. We treated a 40-year-old woman with a compromised tooth in the esthetic zone, presenting clinical and radiological signs of infection, particularly a periapical periodontitis. The tooth was extracted after administering local anesthesia using Optocain® (mepivacaine and adrenalin 1 : 100,000), following which the site was treated with an ErCr : YSGG (erbium, chromium-doped yttrium, scandium, gallium, and garnet) 2780 nm laser device (Biolase iPlus®). The implant (Straumann® fixture) was inserted with minimum 35 N torque, 1 mm below the most apical bone peak. Bio-Oss® and resorbable membrane were applied to improve bone healing. The use of ErCr : YSGG laser has ensured success of implant therapy performed on an infected site. There were no complications such as peri-implantitis or loss of peri-implant bone. The implant achieved good primary stability, immediate placement into an infected site did not increase complications, and the 5-year follow-up confirmed the treatment success.

1. Introduction

Placement of postextraction dental implants has become a common practice, due to its numerous advantages, such as it facilitated maintenance of the horizontal and vertical dimensions of the osseous tissues [1], reduced treatment times, enhanced patient comfort, and good esthetic results. The immediate implant placement technique was first described by Lazzara in 1989 [2]. However, only a small number of studies report the clinical outcomes of immediate implants inserted in postextraction sockets.

One of the primary indications to this technique is the need to replace endodontically compromised teeth in cases when periapical surgery is inadvisable [3]. In such cases, it is imperative to note that certain local and systemic factors may contraindicate placement of the dental implant [4]. Recent studies have demonstrated that the presence of a periradicular infection may not compromise immediate implant placement, provided that the site is adequately decontaminated with a disinfection protocol [5]. The YSGG laser can significantly reduce the bacterial concentration present in the socket of an extracted tooth [6].

A number of studies have reported high success rates for immediately placed, in some cases immediately loaded, implants that are inserted in infected or inflamed postextraction sites [7]. However, to ensure the success of this technique, it is imperative to establish certain preoperative and postoperative measures, such as meticulous cleansing,

alveolar debridement, administration of antibiotics, and postoperative 0.12% chlorhexidine mouth rinses [8].

Recent studies have reported that laser technology is capable of eliminating bacteria more effectively than chemical products. Kusek suggests that the hydroacoustic phenomenon, which combines bactericidal effects with the ability to reach anatomically complex regions, is the principal factor that ensures complete disinfection [6]. The article reviews the studies concerning the immediate implant technique after laser disinfection and presents a clinical case to illustrate the main steps for correct management of the procedure and the 5-year follow-up.

2. Case Report

We encountered the case of a 40-year-old woman with a compromised upper left lateral incisor presenting with clinical and radiological signs of an infection, particularly periapical periodontitis (Figures 1 and 2). The tooth had been unsuccessfully treated with apicectomy. The patient was in good general health and had a good oral hygiene and was motivated to begin the treatment. We decided to proceed with a postextraction dental implant, considering the conditions and the area of high esthetic value.

Optocain® (mepivacaine 1 : 100.000) was used as local anesthetic, and tooth 2.2 was extracted as atraumatically as possible. The full thickness flap was carried out by a crestal incision with vertical releases. The postextraction site was treated with the ErCr : YSGG 2780 nm laser device Waterlase iPlus® (Biolase) with handpiece gold having two modes of operation, namely, the soft tissue and hard tissue modes (Figure 3). Configuration for the soft tissue mode includes tip MC-3, length 9 mm, air 20%, and water 40%; alternatively, the configuration for the hard tissue mode includes tip MZ-8, length 9 mm, air 40%, water 60%, 3.5 W, and 60 Hz. The site was debrided and decontaminated after extraction using the same laser device (2.0 W, 15 Hz, 40% air, 60% water, and 100 mL H_2O/min in hard tissue mode) while mounting a MZ-6 tip and 9 mm in length. Debridement time depended on the amount of pathological tissue and bone volume, whereas decontamination lasted from 60 to 90 seconds per socket, ensuring no physical contact between the tip and the tissues. Straumann® fixtures were selected for the implant surgery. The implant (1 T.E. ø 3.3 mm RN, SLA®; 10 mm, Roxolid®) was inserted with a minimum 35 N torque and 1 mm below the most apical bone peak. Bio-Oss® and GUIDOR matrix barrier (DeOre Materials®) were used to improve bone healing (Figures 4 and 5). The suture was placed with particular care to obtain primary closure over the implant. The suturing material used was PTFE Omnia 3/0, 19 mm 3/8. We postoperatively administered amoxicillin (1 gr ×2/day for 6 days) and chlorhexidine gluconate 0.20% twice daily for 15-20 days. The temporary prosthetic phase before loading was managed with a Maryland bridge. The implant was loaded after 4 months, and a clinical check 2 years later demonstrates satisfactory esthetic outcomes (Figure 6). Radiographic checkups were scheduled on the 1st, 4th, 8th, and 12th months in the first year (Figure 7).

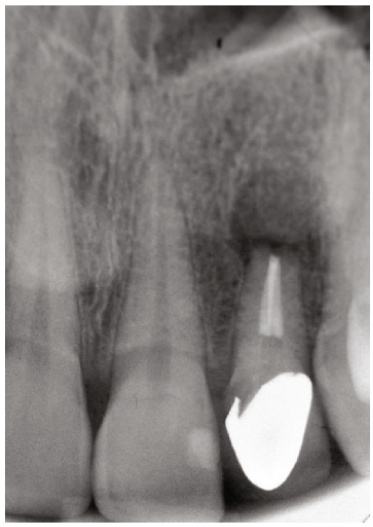

Figure 1: Preoperative X-ray.

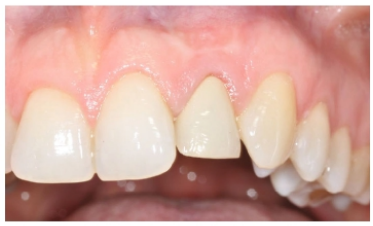

Figure 2: Preoperative clinical condition.

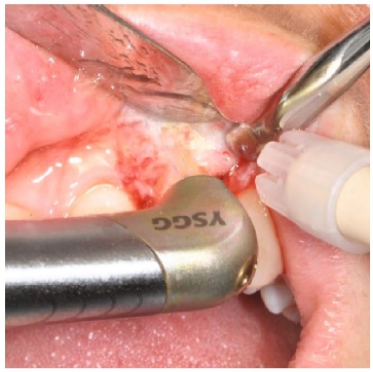

Figure 3: Phases of surgery.

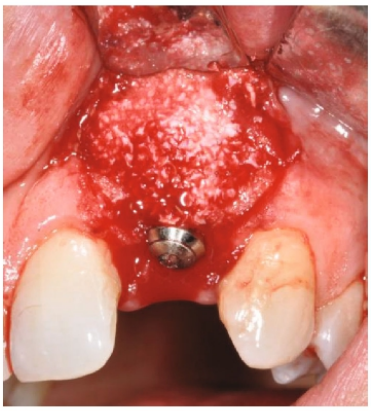

Figure 4: Tissue regeneration.

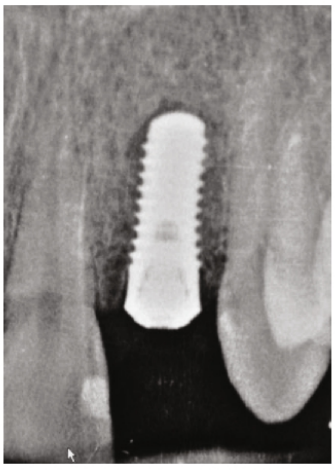

Figure 5: Postoperative X-ray.

3. Discussion

We did not observe any complications, such as implant loss, peri-implantitis, or loss of the peri-implant bone. The implant achieved a good primary stability (>35 N/cm) and indicated that immediate placement into infected sites does not lead to more number complications than the traditional technique. This is evidenced by the 5-year follow-up (Figure 8) and research performed to analyze the scientific literature. The PICO assessment worksheet was used to define the topic and plan the search strategy, before commencing the review [9]. We searched for the studies including those limited to the period from January 1, 1980, to June 30, 2019. Furthermore, we used a specific set of keywords such as "immediate implant placement" AND "laser", "dental implants" AND "laser" AND "postextraction". The search was restricted to the study subjects due to the use of Boolean connectives. We used the PubMed (Medline) search engine and the NCBI database. All types of studies published in dental journals were considered.

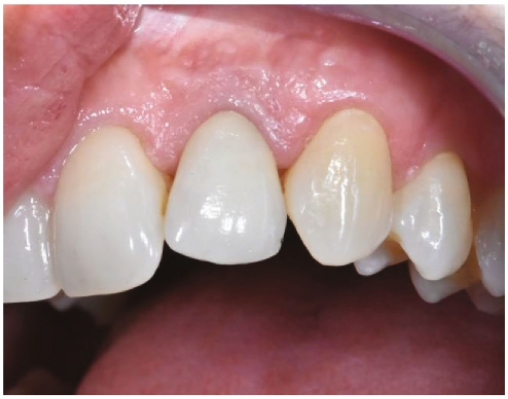

Figure 6: Clinical conditions after 2 years.

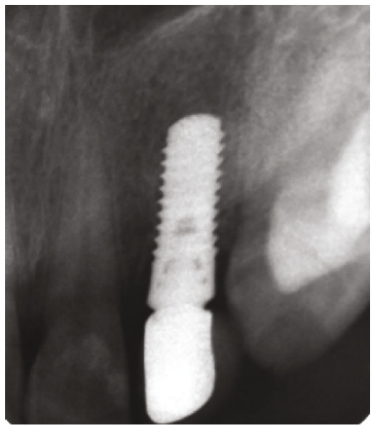

Figure 7: 1-year follow-up.

Although the postextraction implant placement technique has been widely validated, little has been reported concerning the applications of laser decontamination of the infected sites for immediate implant placement. A search through the published studies produced only four clinical articles that combined laser treatment and immediate implant therapy (Table 1). Kusek presented 10 cases of immediate implant placement subjected to the ErCr : YSGG laser disinfection therapy and affirmed that these cases would have taken 3 times longer to heal if treated through traditional methods. Using this technique would therefore enable both the patient and dentist to benefit from a reduced treatment time [6].

Montoya-Salazar et al. also reported a similar study: they analyzed 36 immediate implants replacing teeth lost due to chronic periapical lesions, with a history of endodontic

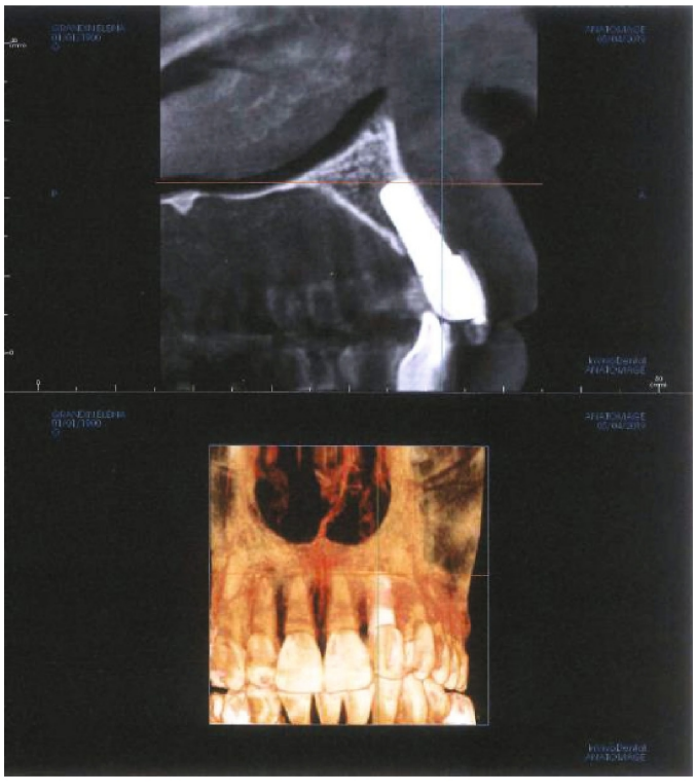

Figure 8: 5-year follow-up.

Table 1: Articles about laser treatment and immediate implant therapy.

Author	Study design	Infected sites	Laser	Implants (no.)	Follow-up	Survival rate
Kusek	Case series	Yes	ErCr : YSGG	10	1 year	10/10
Montoya-Salazar et al.	Prospective	Yes	ErCr : YSGG	18	3 years	17/18
Crippa et al.	Case series	Yes	ErCr : YSGG	94	6 months/4 years	89/94
Choi et al.	Case series	No	Nd : YAG	6	9 months	6/6

failure, and concluded that this therapy may be considered safe option to restore fresh infected postextraction sockets, provided that a strict debridement protocol was respected. Their protocol comprised curettage, cleansing with 90% hydrogen peroxide, irradiation with ErCr : YSGG laser, and chlorhexidine rinses, together with guided bone regeneration under antibiotic cover [7].

Crippa et al. described a series of 94 postextraction implants with a follow-up from 6 months to 4 years and a success rate of 94.6% (89/94) [10].

Additionally, Choi et al. described the advantages of using the laser for ridge conservation. However, that study was not pertinent to infected sites. The authors affirmed that using the Nd : YAG laser energy with 650 μs pulse duration consistently supported rapid clot formation and graft containment at immediate implant and ridge preservation sites [11].

An important systematic review of the literature on immediate implants in infected sites was carried out by Waasdorp et al., but it does not include studies on the effects of laser decontamination [12].

Success after 5 years of follow-ups, the case described in this work reflects what the other authors observed in previous studies. According to the current scientific evidence, provided the presence of adequate primary stability, the implant immediate placement into infected sites would not present with increased rate of complications. However, according to the studies reviewed, it is imperative to conduct

an RCT study on this objective, while following appropriate clinical protocol.

The effectiveness of the YSGG laser in disinfecting the surgical site depends on the photoacoustic effect of laser radiation, which attacks bacterial colonies [13, 14]. This effect has been extensively studied in vitro, through experiments that have demonstrated its validity [15, 16]. An important factor is the power setting of the laser: the power must be adjusted to ensure optimum disinfection of the site without risking collateral tissue damage [17]. Moreover, the operator's experience with this technique also plays a fundamental role. Using the laser device for implant surgery may also be advantageous in reducing intraoperative bleeding, therefore keeping the operative field clear [18].

4. Conclusion

Immediate implant placement in infected or inflamed postextraction sites, after laser decontamination, does not seem to increase the risk of failure, as demonstrated by this case and other previously published reports. The technique also offers interesting advantages of treating esthetic areas with postextraction implants. It is necessary to follow a certain set of protocols and procedures to prevent peri-implantitis and infective complications. However, further studies will undoubtedly be needed to fully elucidate the importance and mechanism underlying the technique.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

References

[1] S. W. Chang, S. Y. Shin, J. R. Hong et al., "Immediate implant placement into infected and noninfected extraction sockets: a pilot study," *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics*, vol. 107, no. 2, article S1079210408004320, pp. 197–203, 2009.

[2] R. J. Lazzara, "Immediate implant placement into extraction sites: surgical and restorative advantages," *International Journal of Periodontics and Restorative Dentistry*, vol. 9, no. 5, pp. 332–343, 1989.

[3] P. Diz, C. Scully, and M. Sanz, "Dental implants in the medically compromised patient," *Journal of Dentistry*, vol. 41, no. 3, pp. 195–206, 2013.

[4] J. A. H. Lindeboom, Y. Tjiook, and F. H. M. Kroon, "Immediate placement of implants in periapical infected sites: a prospective randomized study in 50 patients," *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics*, vol. 101, no. 6, pp. 705–710, 2006.

[5] D. W. Siegenthaler, R. E. Jung, C. Holderegger, M. Roos, and C. H. F. Hämmerle, "Replacement of teeth exhibiting periapical pathology by immediate implants: a prospective, controlled clinical trial," *Clinical Oral Implants Research*, vol. 18, no. 6, pp. 727–737, 2007.

[6] E. R. Kusek, "Immediate implant placement into infected sites: bacterial studies of the Hydroacoustic effects of the YSGG laser," *Journal of oral implantology*, vol. 37, no. sp1, pp. 205–211, 2011.

[7] V. Montoya-Salazar, R. Castillo-Oyagüe, C. Torres-Sánchez, C. D. Lynch, J. L. Gutiérrez-Pérez, and D. Torres-Lagares, "Outcome of single immediate implants placed in post-extraction infected and non-infected sites, restored with cemented crowns: a 3-year prospective study," *Journal of Dentistry*, vol. 42, no. 6, pp. 645–652, 2014.

[8] S. Marconcini, A. Barone, F. Gelpi, F. Briguglio, and U. Covani, "Immediate implant placement in infected sites: a case series," *Journal of Periodontology*, vol. 84, no. 2, pp. 196–202, 2013.

[9] S. A. Miller and J. L. Forrest, "Enhancing your practice through evidence-based decision making: PICO, learning how to ask good questions," *Journal of Evidence-Based Dental Practice*, vol. 1, no. 2, article S1532338201700243, pp. 136–141, 2001.

[10] R. Crippa, R. Aiuto, M. Guardincerri, M. Peñarrocha Diago, and F. Angiero, "Effect of laser radiation on infected sites for the immediate placement of dental implants," *Photobiomodulation, photomedicine, and laser surgery*, 2019.

[11] A. Y. Choi, C. M. Reddy, R. T. McGary et al., "Adjunctive Nd:YAG laser irradiation for ridge preservation and immediate implant procedures: a consecutive case series," *Clinical advances in periodontics*, vol. 9, no. 3, pp. 125–134, 2019.

[12] J. A. Waasdorp, C. I. Evian, and M. Mandracchia, "Immediate placement of implants into infected sites: a systematic review of the literature," *Journal of Periodontology*, vol. 81, no. 6, pp. 801–808, 2010.

[13] M. E. Licata, A. Albanese, G. Campisi, D. M. Geraci, R. Russo, and G. Gallina, "Effectiveness of a new method of disinfecting the root canal, using Er, Cr:YSGG laser to kill Enterococcus faecalis in an infected tooth model," *Lasers in medical science*, vol. 30, no. 2, article 1410, pp. 707–712, 2015.

[14] U. Schoop, W. Kluger, A. Moritz, N. Nedjelik, A. Georgopoulos, and W. Sperr, "Bactericidal effect of different laser systems in the deep layers of dentin," *Lasers in Surgery and Medicine*, vol. 35, no. 2, pp. 111–116, 2004.

[15] A. Moritz, O. Doertbudak, N. Gutknecht, K. Goharkhay, U. Schoop, and W. Sperr, "Nd: YAG laser irradiation of infected root canals in combination with microbiological examinations," *The Journal of the American Dental Association*, vol. 128, no. 11, pp. 1525–1530, 1997.

[16] W. Gordon, V. A. Atabakhsh, F. Meza et al., "The antimicrobial efficacy of the erbium, chromium:yttrium-scandium-gallium-garnet laser with radial emitting tips on root canal dentin walls infected with Enterococcus faecalis," *Journal of the American Dental Association*, vol. 138, no. 7, pp. 992–1002, 2007.

[17] L. Zhu, M. Tolba, D. Arola, M. Salloum, and F. Meza, "Evaluation of effectiveness of Er,Cr:YSGG laser for root canal disinfection: theoretical simulation of temperature elevations in root dentin," *Journal of Biomechanical Engineering*, vol. 131, no. 7, article 071004, 2009.

[18] R. Crespi, P. Capparè, and E. Gherlone, "Fresh-socket implants in periapical infected sites in humans," *Journal of Periodontology*, vol. 81, no. 3, pp. 378–383, 2010.

IMPIANTI POSTESTRATTIVI INSERITI IN SITI INFETTI DECONTAMINATI CON IL LASER: STUDIO DI COORTE RETROSPETTIVO

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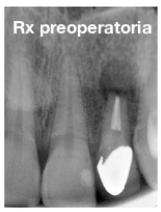
Obiettivi

Negli ultimi anni, **gli impianti post-estrattivi (tipo 1, Hammerle et al.) rappresentano una valida alternativa terapeutica** in chirurgia orale, che consente di finalizzare la riabilitazione in tempi più brevi e con un minor discomfort per il paziente. Il presente studio si prefigge l'obiettivo di analizzare il successo clinico di una serie di impianti post-estrattivi inseriti **in siti infetti decontaminati con il Er,Cr:YSGG laser**. L'obiettivo secondario riguarda l'analisi di fattori come il fallimento, complicanze cliniche e la perdita di osso marginale (MBL).

Materiali e metodi

Attraverso una analisi retrospettiva, è stato studiato il successo degli impianti post-estrattivi in siti infetti (gruppo test) e comparato con quello di una serie di impianti (gruppo controllo) inseriti in zone edentule (impianti tipo 4). Il criterio di inclusione prevede pertanto che il paziente abbia ricevuto almeno uno dei due trattamenti, con almeno 12 mesi di follow-up. Il calcolo della dimensione del campione è stato eseguito per rilevare una differenza di 0,2 mm nella perdita di osso tra i due gruppi: utilizzando una deviazione standard di 0,22 mm (Montoya-Salazar et al.), α = 0,05 (errore di tipo I), almeno 20 pazienti per gruppo devono essere annoverati per raggiungere l'80% di potenza (errore di tipo II di 0,20). Per l'analisi radiografica, è stata effettuata la calibrazione del misuratore a 2 settimane di distanza. È stato poi calcolato il coefficiente di correlazione per l'analisi della concordanza ed è stato utilizzato un modello a effetti misti REML (REstricted Maximum Likelihood).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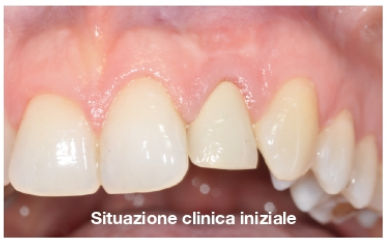
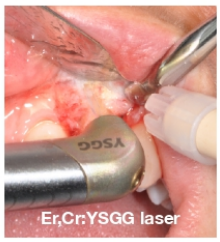
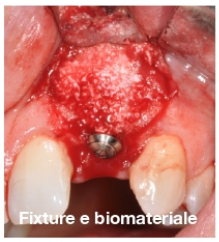
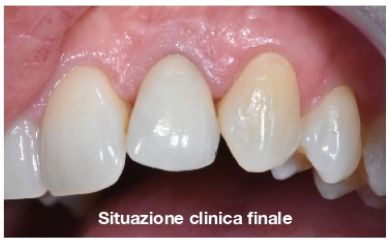

Situazione clinica iniziale


Er,Cr:YSGG laser


Fixture e biomateriale

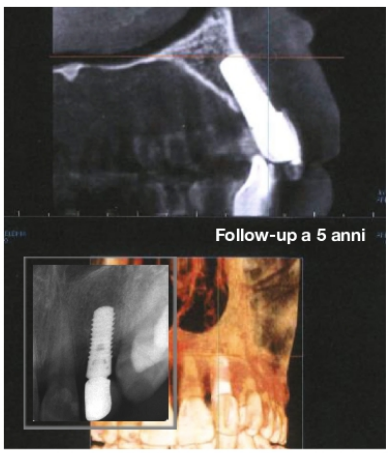

Situazione clinica finale

Risultati

I risultati preliminari mostrano il successo degli impianti post-estrattivi nei siti infetti: 150 impianti sono stati coinvolti nello studio; si è registrato un solo fallimento nel gruppo test, mentre un altro impianto è andato incontro a complicanze cliniche (mucosite). Nessun impianto del gruppo controllo, invece, ha fatto registrare delle problematiche. Tutti gli impianti (Straumann®) sono stati inseriti con un valore di torque minimo di 35N, 1 mm al di sotto del picco osseo più apicale; 29 impianti impianti hanno ricevuto un carico immediato. In molti casi, sono stati utilizzati Bio-Oss® e membrana riassorbibile in collagene per la gestione dell'alveolo post-estrattivo. **Nessun alveolo ha presentato segni di infezione residua al follow-up.**

Conclusioni

La tecnica di posizionamento di impianti tipo 1 in alveoli post-estrattivi non sembra far registrare un rischio aumentato di fallimento, a condizione che vengano seguite determinate procedure cliniche. Entro i limiti di questo studio, la decontaminazione laser (Er,Cr:YSGG) di un alveolo infetto rappresenta uno strumento efficace per prevenire complicanze quando si inseriscono impianti in siti post-estrattivi. **Sono tuttavia necessari ulteriori studi per approfondire il ruolo preciso dell'irradiazione laser in questo contesto**.


Follow-up a 5 anni

Bibliografia:

1. Hammerle CH, Chen ST, Wilson TG. Consensus statements and recommended clinical procedures regarding the placement of implants in extraction sockets. Int J Oral Maxillofac Implants 2004;19 Suppl, 26-28.
2. Paolantonio M, Dolci M, Scarano A, d'Archivio D, di Placido G, Tumini V, Piattelli A. Immediate implantation in fresh extraction sockets. A controlled clinical and histological study in man. J Periodontol 2001;72:1560-1571.
3. Chang SW, Shin SY, Hong JR, et al. Immediate implant placement into infected and non infected extraction sockets: a pilot study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009;107: 197–203.
4. Crippa R, Aiuto R, Guardincerri M, Peñarrocha Diago M, Angiero F. Effect of laser radiation on infected sites for the immediate placement of dental implants. Photobiomodulation, photomedicine, and laser surgery, 2020 Mar; 38(3):186-192.
5. Crippa R, Aiuto R, Dioguardi M, Peñarrocha-Diago M, Peñarrocha-Diago M, Angiero F. Laser Therapy for Infected Sites and Immediate Dental Implants in the Esthetic Zone: A Case Report and Review of Literature. Case Rep Dent. 2020 Jan 7;2020:2328398.

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LASER IN ODONTOSTOMATOLOGIA

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MENZIONE D'ONORE

Clinical procedures for immediate dental implant placement in post-extraction-infected sites decontaminated with Er,Cr:YSGG laser

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KEYWORDS

Laser therapy; Dental implant; Oral surgery; Tooth extraction.

ABSTRACT

Aim: *Placement of dental implants into fresh extraction sockets offers some advantages, such as reduced treatment times and enhanced patient comfort. The Er,Cr:YSGG (Erbium, Chromium-doped: Yttrium, Scandium, Gallium, and Garnet) laser can significantly reduce bacterial concentration after the extraction of a compromised tooth. The aim of this article is to provide a clinical protocol for the management of implants placed in infected extraction sites decontaminated with Er,Cr:YSGG laser.*

Methods: *A compromised tooth, which was an abutment for a fixed bridge, with clinical and radiological signs of infection was extracted. The infected site was treated and decontaminated with an Er,Cr:YSGG laser device (Biolase iPlus®) and two implants (Straumann®) were placed in the same surgery, in order to rehabilitate the edentulous area. The intervention was completed by tissue regeneration with biomaterials.*

Results: *Prosthetic rehabilitation after the surgical phase allowed us to provide correct function and satisfactory esthetics. In the follow-up visit, clinicians found good tissue healing and did not observe any complications, such as implant loss or peri-implantitis. The technique used in our study is repeatable and predictable, but patient selection is very important for this type of protocol as the presence of contraindications can lead to failure. The photoacoustic effect exerted by this type of laser has been proven to be effective against many pathogens. Several authors have previously demonstrated the effectiveness of this technique.*

Conclusion: *Immediate implantation in infected sites decontaminated with Er,Cr:YSGG laser does not seem to contribute to an increased risk of failure; however, it is necessary to follow a certain set of protocols and procedures to prevent peri-implantitis and other complications.*

Introduction

In recent years, the immediate insertion of an implant after tooth extraction (Type 1 implant insertion protocol) (1) has become a common treatment option. The surgical technique for immediate placement of a dental implant in an extraction socket was initially proposed in 1976 by Schulte and Heimke (2). Proponents of this protocol claimed that by reducing the patient's surgical exposure, there was limited physiological bone resorption after tooth extraction (3). Clinical studies have been conducted to confirm the validity of this technique (4) and it has been studied and successfully applied to different types of implant-prosthetic rehabilitation (5). Placement of dental implants into fresh extraction sockets offers advantages such as reduced treatment times and enhanced patient comfort (6).

The extraction of a tooth is often linked to the presence of a periapical lesion indicating an active infection. This is considered to be one of the main contraindications to immediate implant insertion because of the increased possibility of infection spreading to peri-implant tissues during the healing period (7). However, animal studies showed that the presence of active periodontal or endodontic infections did not compromise the osseointegration of immediately placed implants.

Additionally, bone-to-implant contact (BIC) was not compromised (8-12). An ever-increasing number of authors describe the possibility of implant placement in post-extraction-infected sites, if the indications exist and if a strict decontamination protocol is respected. In a systematic review of the literature, Corbella et al. identified nine human studies reporting survival rates ranging between 92% and 100% for a total of 497 implants placed in sites with endodontic infections; the follow-up varied from 3 to 117 months from loading (13).

Different approaches have been proposed by different authors for the decontamination of the post-extraction site prior to receiving the fixture. Marconcini et al. proposes tooth extraction with extreme care to preserve the alveolar bony integrity and careful curettage of the sockets to remove the remaining granulation tissue (14). Measures to decrease the bacterial load of infected sites include the administration of antibiotics and chlorhexidine mouth rinses. In a cohort study, Del Fabbro et al. described a similar protocol, but with the addition of plasma rich growth factors (PRGF) in infected sockets (15). Other authors, in order to obtain thorough decontamination and limit cases of failure, added the use of lasers to the clinical protocol. The first case series was described by Kusek with 10 immediate implants (16). Later, Montoya-Salazar et al., Crippa et al., and Kakar et al. performed different studies with 18, 94, and 110 immediate implants, respectively (17-19); all clinical trials used Er,Cr:YSGG lasers to decontaminate post-extraction sites.

The aim of this article is to provide a clinical protocol for the management of post-extraction implants placed in infected sites decontaminated with Er,Cr:YSGG lasers, accompanied by a case report which successfully demonstrates the technique. The clinical procedure described is the result of the authors' extensive experience in the field as well as the scientific literature supporting the topic.

Materials and methods

The case concerned a 61-year-old female patient in good general health, who presented with pain in the mandibular left first molar (36), which was a prosthetic element of a bridge (Fig. 1, 2). Clinical examination, periodontal probing, and radiographs suggested a root fracture in tooth 36. The patient consented to a treatment plan involving the extraction of the compromised tooth, decontamination of the site using the Er,Cr:YSGG laser, and the placement of two fixtures in the same clinical session, in order to replace the missing tooth 35 and the compromised tooth 36 with a fixed implant prosthesis. The treatment plan was agreed upon after a careful analysis that excluded the presence of contraindications, such as poor oral hygiene or smoking. The patient gave her informed consent for the study.

The patient had started antibiotic therapy (amoxicillin, 1 g twice daily for 6 days) the evening before surgery. The local anesthetic used in the intervention was Optocain® (Mepivacaine 1:100.000). After sectioning the bridge, tooth 36 was extracted as atraumatically as possible to safeguard the surrounding tissues, assisted by the Er,Cr:YSGG laser (Fig. 3, 4). The full-thickness flap was raised by the laser with the following settings: configuration for the soft tissue mode, which included tip MC-3, length 9 mm, air 20%, and water 80%. For bone tissue, the setting mode included tip MZ-8, length 6 mm, air 40%, and water 60%. Once extraction was completed, the decontamination phase of the infected site began (Fig. 5). The site was debrided and decontaminated after extraction using the same laser device but with another setting: 2.0W, 20% air, and 80% water, while mounting a MZ-6 tip, 9 mm in length. Debridement time depended on the amount

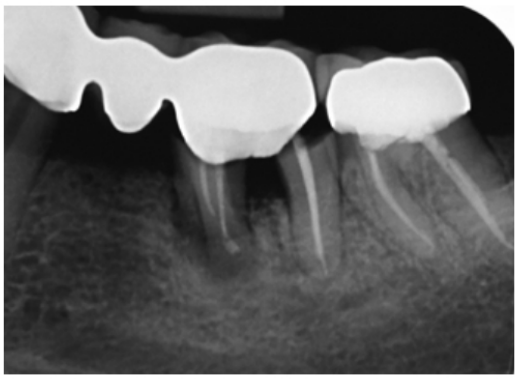

Figure 1 Preoperative x-ray

Figure 2 Preoperative clinical condition

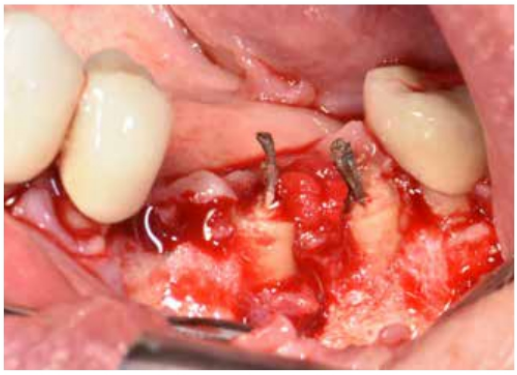

Figure 3 Root fracture

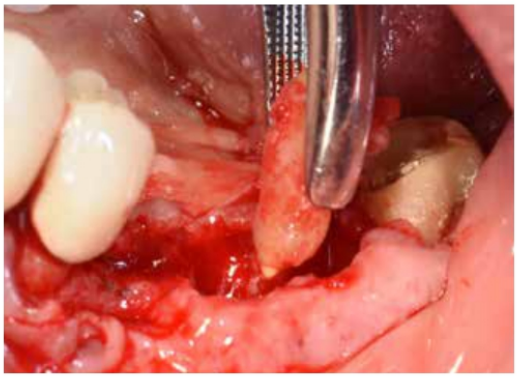

Figure 4 Tooth extraction

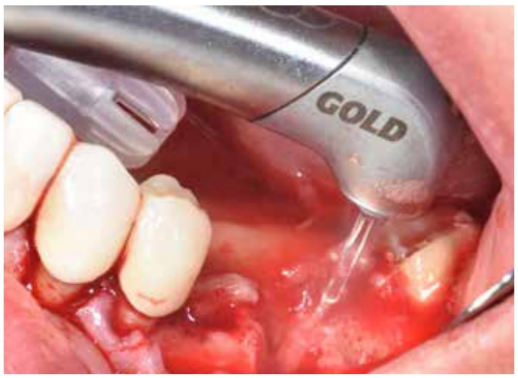

Figure 5 Socket debridement and disinfection

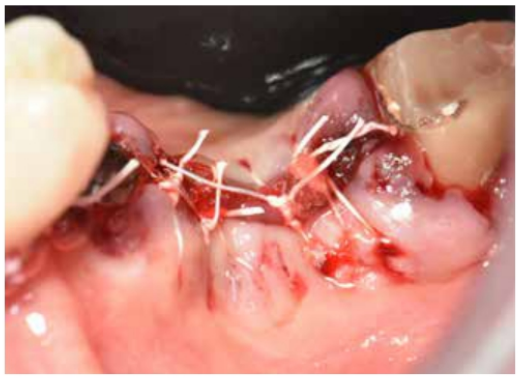

Figure 6 Suturing

of pathological tissue and bone volume, whereas decontamination lasted from 60 to 90 seconds per socket, ensuring no physical contact between the tip and the tissues. The Waterlase iPlus® (Biolase) device was used for all laser procedures.

The subsequent phases of the intervention involved the placement of two implants (Straumann®). The fixtures (SLActive® S, Ø 3.3 mm, RN, 10 mm length to replace tooth 35 and 8 mm to replace tooth 36) were placed with a minimum 35N torque and 1 mm below the most apical bone peak. It was also necessary to place biomaterials for the residual defect caused by the infection: collagen (Septodont®) and an absorbable membrane (Collprotect®) were used to improve tissue healing. Sutures (PTFE 3/0 Gore®) were placed with particular care to obtain good flap repositioning (Fig. 6). Subsequently, chlorhexidine gluconate gel 0.2% twice daily for 15-20 days was prescribed, and post-operative instructions were given to the patient. Periodic clinical and radiographic checks were scheduled (Fig. 7), and the implants were loaded after 4 months.

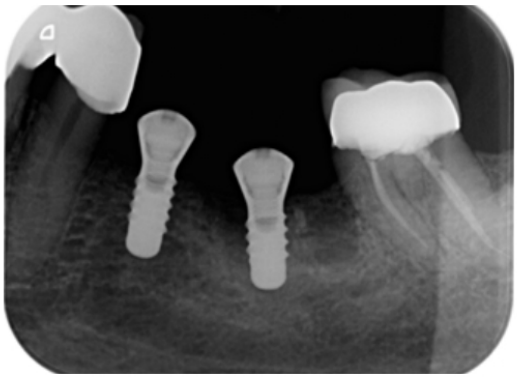

Figure 7 Postoperative x-ray

Results

During the follow-up visit, we did not observe any complications, such as implant loss, peri-implantitis, or loss of the peri-implant bone. Implants achieved a good primary stability (>35 N/cm). Prosthetic

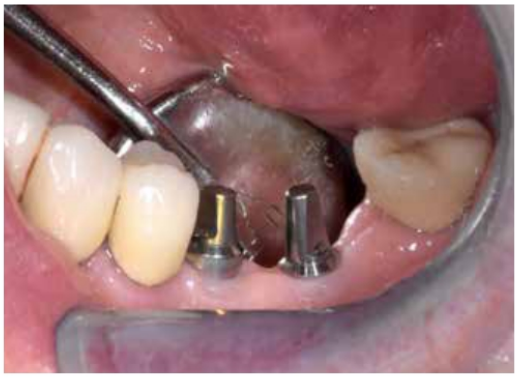

Figure 8 Tissue healing and prosthetic step

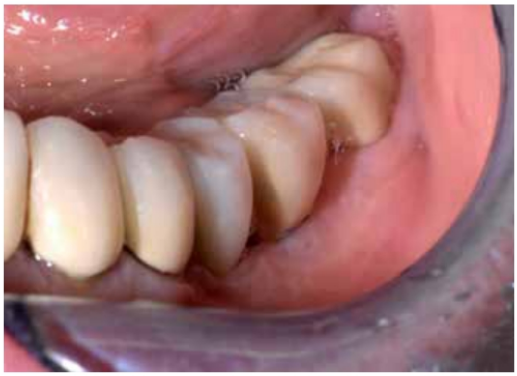

Figure 9 Definitive prosthesis

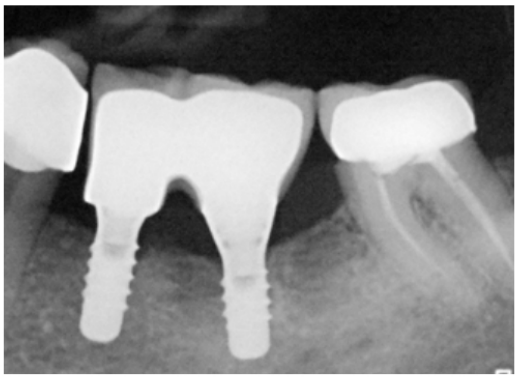

Figure 10 3-years follow-up

rehabilitation after the surgical phase allowed us to obtain satisfactory function and esthetics (Fig. 8, 9). The success of implant therapy is highlighted by clinical and radiographic controls (Fig. 10). Similar successful cases have been reported in other studies, with follow-ups of up to 5 years (20). The technique is repeatable and predictable, and this case describes the salient steps; however, candidate selection is very important for the success of this protocol.

According to the authors' experience, some rules must be considered.

- The patient must be healthy, a non-smoker, and must not have untreated periodontitis. The patient must be co-operative and adhere to the dentist's instructions.
- The clinical case must be carefully assessed in advance: the cause of tooth extraction, the possible presence of recurrent infections, the type of bone, etc. Therefore, evaluation of radiographs (and CBCT if appropriate) is also necessary.
- Prophylaxis for surgery involves antibiotic therapy and chlorhexidine gel 0.2%.
- The extraction must be completed atraumatically to preserve the residual bone.
- Among the various types of lasers, Er,Cr:YSGG is recommended for the best decontamination capacity.
- The use of biomaterials is often necessary to cope with bone defects.

There are several types of lasers available on the market. The authors report settings for the correct use of the Er,Cr:YSGG laser in different substrates (Table 1). It is important to follow the programs of the device to avoid adverse effects to the hard and soft tissues. Operators must comply with all regulations for their own safety and for that of the patient, such as wearing special protective glasses.

Discussion

The laser (light amplification by stimulated emission of radiation) was introduced into dental practice by

Er,Cr:YSGG Laser	TIP	LENGTH	POWER	FREQUENCY	AIR	WATER
Soft tissue	MC-3	9 mm	3.5 W	50 Hz	20%	80%
Hard tissue	MZ-8	6 mm	3.5 W	20 Hz	40%	60%
Decontamination	MZ-6	9 mm	2.0 W	50 Hz	20%	80%

Table 1 Laser parameters

Miaman in the 1960s. Since then, its use has steadily increased and many devices have been developed specifically for different oral conditions. Two categories of lasers can be distinguished. Hard lasers, such as Carbon dioxide (CO2), Neodymium Yttrium Aluminum Garnet (Nd:YAG), Er:YAG and Er,Cr:YSGG, offer both hard tissue and soft tissue applications. Cold or soft lasers, based on the semiconductor diode devices, are broadly termed as low-level laser therapy (LLLT) or "biostimulation" (21). Lasers in the first category are generally more expensive, bulky, and more complex than the latter.

The erbium "family" of lasers has two distinct wavelengths, Er,Cr: YSGG (yttrium scandium gallium garnet) lasers and Er:YAG (yttrium aluminum garnet) lasers. The wavelength of erbium has a high affinity for hydroxyapatite and water. Consequently, it is the most suitable for both hard tissue and soft tissue surgery. The high affinity for water results in a low penetration depth, which allows good surface ablation without compromising deep tissues. Erbium lasers can cut both soft and hard tissues with minimal thermal damage to the surrounding epithelial tissue, resulting in a low incidence of inflammatory reactions and more rapid healing (22). The utilization of Er,Cr:YSGG lasers in dentistry has been studied extensively and in several applications. For example, their use adjunctive to conventional periodontal therapy is reported to be more effective in bacterial reduction, compared with conventional periodontal therapy. Additionally, Er,Cr:YSGG lasers are also successful in coagulation of open blood vessels and deepithelization of the gingival pocket as reported by Dereci et al. Other studies affirm that laser-assisted treatment is a better treatment modality, compared with conventional non-surgical periodontal treatment (23). It has also been reported that ER,Cr, and YSGG lasers enhance cell attachment and migration on root surfaces (24). The Er,Cr:YSGG laser, operating at a wavelength of 2780 nm, has been demonstrated to be a valuable tool in endodontic treatment. Martins et al. demonstrated how a laser-assisted protocol can achieve predictable endodontic outcomes, comparable to conventional strategies (25). Therefore, the photoacoustic effect exerted by this type of laser has proven to be effective against many pathogens. Recent studies have highlighted that laser technology is capable of eliminating bacteria more effectively than chemical products (16).

Regardless of the proven laser decontamination effect, several studies have shown that immediate implants can also be placed in infected sites if certain precautions are taken. In a systematic review, Waasdorp et al. affirm that sites must be thoroughly debrided prior to placement and guided bone regeneration is usually performed to fill the bone-implant gap and/or socket deficiencies (26). From the point of view of bacterial contamination, this reassures clinicians that the infected site would not represent an obstacle regardless of the type of decontamination carried out. However, this article highlights the multiple benefits of laser therapy, such as proven efficacy on pathogens, minimal invasiveness, reduced intraoperative bleeding, increased visualization of the operative field, and good prognosis for tissue healing (27). Certainly, the technique involves a learning curve and requires experience in implantology. There are also some disadvantages, such as the cost of the device. The studies presented by a review on the subject show how immediate placement into infected sites does not lead to an increased rate of complications and does not compromise tissue integration, provided that appropriate clinical procedures are followed to achieve good socket decontamination (20). Therefore, the drawbacks of this technique are comparable to those of type 1 implants positioned in non-infected sites. The main etiology of periodontitis is plaque accumulation, and the evolution from periodontitis to peri-implantitis occurs in the absence of supportive maintenance care.

Periodontal infections are mixed infections caused by different species of aerobic and anaerobic bacteria (28). Dent et al. reported a reduction in implant failures when antibiotics are used pre-operatively (29). Nevertheless, a systematic review suggests that the benefits of antibiotic prophylaxis for non-infected sites are unclear and may not be needed (30,31). It is also important to consider that the presence of some independent systemic (i.e., smoking) and local risk factors (i.e., residual cement, dimensions of the keratinized tissue, and surface roughness) may increase the probability of occurrence of periodontitis (32).

In this clinical protocol, the ErCr:YSGG laser was used

in association with antibiotics and chlorhexidine gel 0.2%. Therefore, it is not possible to determine a clear causal effect of the laser alone in decontamination and good osseointegration of the implants. For this reason, further clinical studies are needed to clarify certain aspects. In any case, the technique is based on current scientific evidence and on clinical experience that promotes immediate placement of implants, even in infected sites.

Conclusion

The protocol for placement of type 1 implants in infected sites performed with Er,Cr:YSGG laser decontamination includes several precautions to avoid complications, but it has several advantages such as the reduction of operating time and patient comfort. This technique does not appear to increase the risk of failure; however, it is necessary to follow a certain set of protocols and procedures to prevent peri-implantitis and infective complications, as outlined in the principles of modern implantology. It would be interesting and useful to deepen the topic with further studies.

Conflicts of interest

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Authors' contributions

M.P., MA.P., R.C. and F.A. have given substantial contributions to the conception or the design of the manuscript, R.A. and M.D. to acquisition, analysis and interpretation of the data. All authors contributed equally to the manuscript and read and approved the final version of the manuscript.

References

1. Hammerle CH, Chen ST, Wilson TG. Consensus statements and recommended clinical procedures regarding the placement of implants in extraction sockets. Int J Oral Maxillofac Implants 2004;19 Suppl, 26-28.
2. Schulte W, Heimke G. The Tubinger immediate implant. Quintessenz. 1976;27:17-23.
3. Paolantonio M, Dolci M, Scarano A, d'Archivio D, di Placido G, Tumini V, et al. Immediate implantation in fresh extraction sockets. A controlled clinical and histological study in man. J Periodontol 2001;72:1560-1571.
4. Rodrigo D, Martin C, Sanz M. Biological complications and peri-implant clinical and radiographic changes at immediately placed dental implants. A prospective 5-year cohort study. Clin Oral Implants Res. 2012;23(10):1224-31.
5. Peñarrocha-Diago M, Maestre-Ferrín L, Demarchi CL, Peñarrocha-Oltra D, Peñarrocha-Diago M. Immediate Versus Nonimmediate Placement of Implants for Full-Arch Fixed Restorations: A Preliminary Study. Oral Maxillofac Surg, 69 (1), 154-9.
6. Koh RU, Rudek I, Wang HL. Immediate implant placement: positives and negatives. Implant Dent. 2010;19(2):98-108.
7. Schwartz-Arad D, Chaushu G. The ways and wherefores of immediate placement of implants into fresh extraction sites: a literature review. J Periodontol. 1997;68:915–923.
8. Chang S-W, Shin S-Y, Hong J-R, et al. Immediate implant placement into infected and noninfected extraction sockets: a pilot study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009;107: 197–203.
9. Novaes A Jr, Marcaccini A, Souza S, Taba MJ, Grisi MF. Immediate placement of implants into periodontally infected sites in dogs: a histomorphometric study of bone-implant contact. Int J Oral Maxillofac Implants. 2003;18:391–398.
10. Marcaccini M, Novaes AJ, Souza S, Taba MJ, Grisi MF. Immediate placement of implants into periodontally infected sites in dogs. Part 2: a fluorescence microscopy study. Int J Oral Maxillofac Implants. 2003;18:812–819.
11. Novaes AJ, Papalexiou V, Grisi M, Souza SS, Taba M Jr, Kajiwara JK. Influence of implant microstructure on the osseointe- gration of immediate implants placed in periodontally infected sites. A histomorphometric study in dogs. Clin Oral Implants Res. 2004;15:34–43.
12. Papalexiou V, Novaes A Jr, Grisi M, Souza SS, Taba M Jr, Kajiwara JK. Influence of implant microstructure on the dynamics of bone healing around immediate implants placed into periodontally infected sites. A confocal laser scanning microscopic study. Clin Oral Implants Res. 2004;15:44–53.
13. Corbella S, Taschieri S, Tsesis I, Del Fabbro M. Postextraction implant in sites with endodontic infection as an alternative to endodontic retreatment: a review of literature. J Oral Implantol. 2013;39(3):399-405.
14. Marconcini S, Barone A, Gelpi F, Briguglio F, Covani U. Immediate implant placement in infected sites: a case series. Journal of Periodontology, vol. 84, no. 2, pp. 196–202, 2013.
15. Del Fabbro M, Boggian C, Taschieri S. Immediate implant placement into fresh extraction sites with chronic periapical pathologic features combined with plasma rich in growth factors: preliminary results of a single-cohort study. J Oral Maxillofac Surg. 2009;67:2476–2484.
16. Kusek ER. Immediate implant placement into infected sites: bacterial studies of the Hydroacoustic effects of the YSGG laser. Journal of oral implantology, vol. 37, no. sp1, pp. 205–211, 2011.
17. Montoya-Salazar V, Castillo-Oyagüe R, Torres-Sánchez C, Lynch CD, Gutiérrez-Pérez JL, Torres-Lagares D. Outcome of single immediate implants placed in postextraction infected and non-infected sites, restored with cemented crowns: a 3-year prospective study. Journal of Dentistry, vol. 42, no. 6, pp. 645–652, 2014.
18. Crippa R, Aiuto R, Guardincerri M, Peñarrocha Diago M, Angiero F. Effect of laser radiation on infected sites for the immediate placement of dental implants. Photobiomodulation, photomedicine, and laser surgery, 2019.
19. Kakar A, Kakar K, Leventis MD, Jain G. Immediate implant placement in infected sockets: A consecutive cohort study. J Lasers Med Sci. 2020;11(2):167-173.
20. Crippa R, Aiuto R, Dioguardi M, Peñarrocha-Diago M, Peñarrocha-Diago M, Angiero F. Laser Therapy for Infected Sites and Immediate Dental Implants in the Esthetic Zone: A Case Report and Review of Literature. Case Rep Dent. 2020 Jan 7;2020:2328398.

21. Verma SK, Maheshwari S, Singh RK, Chaudhari PK. Laser in dentistry: An innovative tool in modern dental practice. Natl J Maxillofac Surg 2012;3:124-32.
22. Matulić N, Bago I, Sušić M, Gjorgievska E, Kotarac Knežević A, Gabrić D. Comparison of Er:YAG and Er,Cr:YSGG Laser in the Treatment of Oral Leukoplakia Lesions Refractory to the Local Retinoid Therapy. Photobiomodul Photomed Laser Surg, 37 (6), 362-368.
23. Dereci O, Hatipoğlu M, Sindel A, Tozoğlu S, Üstün K. The Efficacy of Er,Cr:YSGG Laser Supported Periodontal Therapy on the Reduction of Peridodontal Disease Related Oral Malodor: A Randomized Clinical Study. Head and Face Medicine (2016) 12(1).
24. Hakki SS, Korkusuz P, Berk G, Dundar N, SaglamM, Bozkurt B, et al. Comparison of Er, Cr:YSGG laser and hand instrumentation on the attachment of periodontal ligament fibroblasts to periodontally diseased root surfaces: an in vitro study. J Periodontol. 2010;81:1216–25.
25. Martins M, Carvalho M, Pina-Vaz I, Capelas J, Martins M, Gutknecht N. Outcome of Er,Cr:YSGG laser-assisted treatment of teeth with apical periodontitis: A blind randomized clinical trial. Photomedicine and Laser Surgery (2014) 32(1) 3-9.
26. Waasdorp JA, Evian CI, Mandracchia M. Immediate placement of implants into infected sites: a systematic review of the literature. Journal of Periodontology, vol. 81, no. 6, pp. 801–808, 2010.
27. Romanos G. Current concepts in the use of lasers in periodontal and implant dentistry. J Indian Soc Periodontol. 2015;19(5):490–494.
28. Romeo E, Ghisolfi M, Carmagnola D. Peri-implant Diseases. A Systematic Review of the Literature. Minerva Stomatol. 2004;53(5):215-30.
29. Dent CD, Olson JW, Farish SE, Bellome J, Casino AJ, Morris HF, et al. The influence of preoperative antibiotics on success of endosseous implants up to and including stage II surgery: a study of 2,641 implants. J Oral Maxillofac Surg 1997;55(12 Suppl 5):19–24.
30. Esposito M, Grusovin MG, Talati M, Coulthard P, Oliver R, Worthington HV. Interventions for replacing missing teeth: antibiotics at dental implant placement to prevent complications. Cochrane Database Syst Rev 2008;3:CD004152.
31. Barone A, Marchionni FS, Cinquini C, Panattoni AC, Toti P, Marconcini S, et al. Antibiotic Treatment to Prevent Postextraction Complications: A Monocentric, Randomized Clinical Trial. Preliminary Outcomes. Minerva Stomatol. 2017;66(4):148-156.
32. Rabel A, Kohler SG. Microbiological study on the prognosis of immediate implant and periodontal disease. Mund Kiefer Gesichtschir 2006;10:7–13.

CHIRURGIA ORALE

IMPIANTI IMMEDIATI POST-ESTRATTIVI IN SITI INFETTI CON AUSILIO DEL LASER ER,CR: YSGG (2.780NM)

IMMEDIATE DENTAL IMPLANTS IN INFECTED SITES WITH THE AID OF LASER ER, CR: YSGG (2.780NM)

Viene illustrata la tecnica di implantologia immediata associata alla disinfezione laser e presentato un caso clinico, con follow-up a 5 anni, per chiarire i passaggi principali per una corretta gestione della procedura. Il laser Er,Cr:YSGG 2.780nm può, infatti, ridurre in modo significativo la concentrazione batterica presente nell'alveolo di un dente estratto

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PAROLE CHIAVE
laser Er,Cr:YSGG, terapia laser, impianto dentale immediato, alveolo postestrattivo infetto

KEY WORDS
Er,Cr:YSGG laser, laser therapy, immediate dental implant, post-extraction infected alveolus

L'inserimento di impianti post-estrattivi con la possibilità di riabilitare immediatamente un paziente con edentulia rappresenta una valida opzione terapeutica e una pratica comune in chirurgia orale, grazie all'elevata percentuale di successo e ai suoi numerosi vantaggi: mantenimento delle dimensioni verticale e orizzontale del tessuto osseo, dimezzamento dei tempi di trattamento, aumento in termini di comfort da parte del paziente e buoni risultati estetici[1].

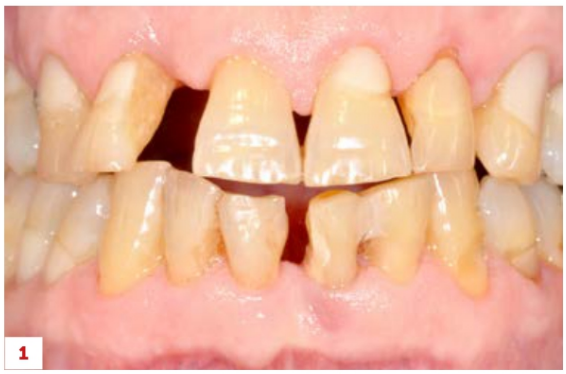
La proposta di inserimento immediato di impianto si deve al contributo di Schulte e Heimke, i quali furono i primi a suggerirla nel 1976, mentre fu Lazzara nel 1989 a descriverne la tecnica di posizionamento[2].

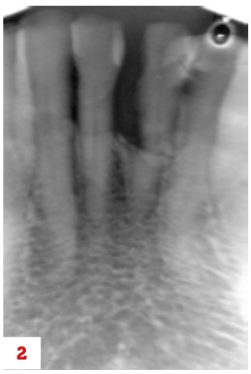
Essa trova la sua indicazione cardine nella necessità di sostituire un dente compromesso endodonticamente nei casi in cui la chirurgia periapicale sia controindicata[3]. In simili circostanze, è d'obbligo notare come fattori locali e sistemici possano impedire l'inserimento di impianti dentali[4]. Recenti studi hanno dimostrato che la presenza di un'infezione periradicolare non sia una controindicazione assoluta per il posizionamento immediato dell'impianto, a condizione che il sito sia adeguatamente decontaminato con un protocollo di disinfezione[5].

Il laser Er,Cr:YSGG 2.780nm può ridurre in modo significativo la concentrazione batterica presente nell'alveolo di un dente estratto[6]. Numerosi studi hanno riportato elevate percentuali di successo per impianti inseriti immediatamente e, in alcuni casi, con carico protesico immediato in siti post-estrattivi infetti o infiammati[7]. Tuttavia, per garantire il successo di questa tecnica, è doveroso stabilire alcune misure preoperatorie e postoperatorie, come una toilette chirurgica meticolosa, lo sbrigliamento alveolare, la somministrazione di antibiotici e risciacqui della bocca con clorexidina allo 0,2% pre e postoperatori[8].

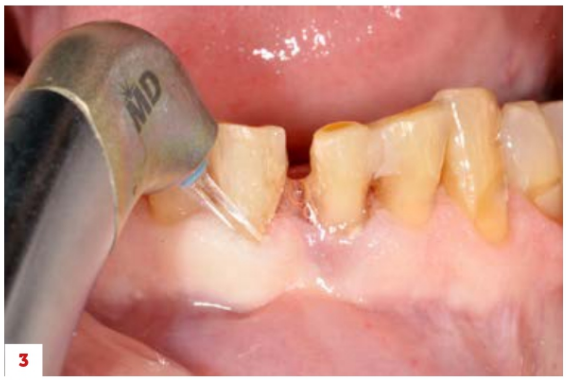
Studi recenti hanno riportato come la tecnologia laser sia in grado di eliminare i batteri in modo più efficace rispetto ai prodotti chimici. Kusek suggerisce che il fenomeno idroacustico, che combina gli effetti battericidi con la capacità di raggiungere regioni anatomicamente complesse, è il fattore principale che garantisce una disinfezione completa e una biostimolazione dei tessuti trattati[6].

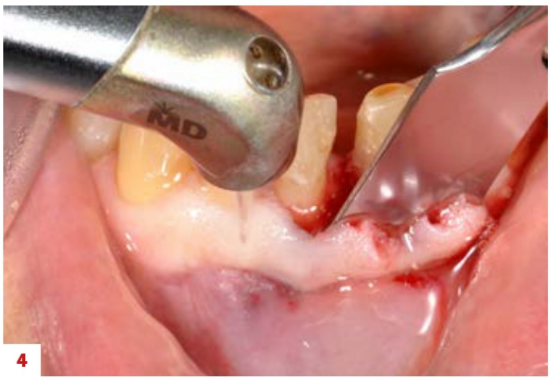
Questo articolo illustra la tecnica di implantologia immediata dopo la disinfezione laser, e presenta un caso clinico, con follow-up a 5 anni, per chiarire i passaggi principali per una corretta gestione della procedura.

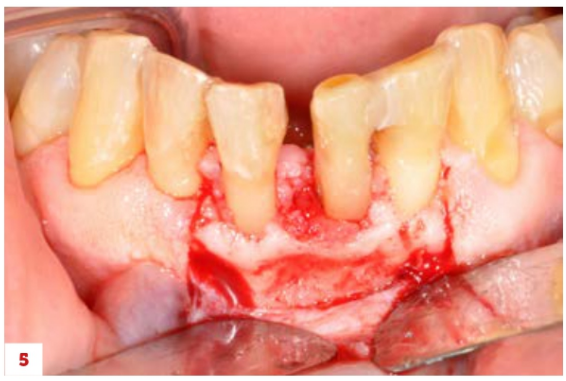


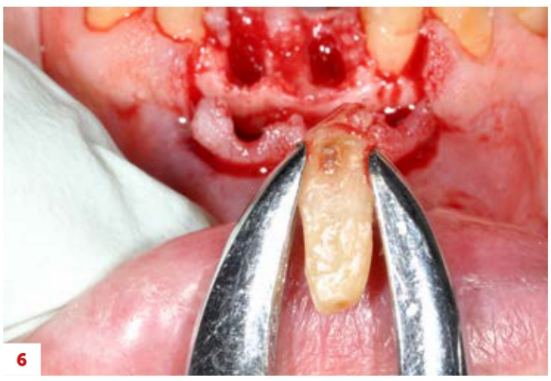


1. Situazione clinica iniziale
2. Radiografia preoperatoria nella quale si apprezza la frattura radicolare dell'elemento 3.1
3. Incisione mediante l'utilizzo del laser Er,Cr:YSGG in modalità soft tissue
4. Allestimento del lembo con incisioni di rilascio
5. Scollamento del lembo
6. Estrazione atraumatica degli elementi dentari compromessi



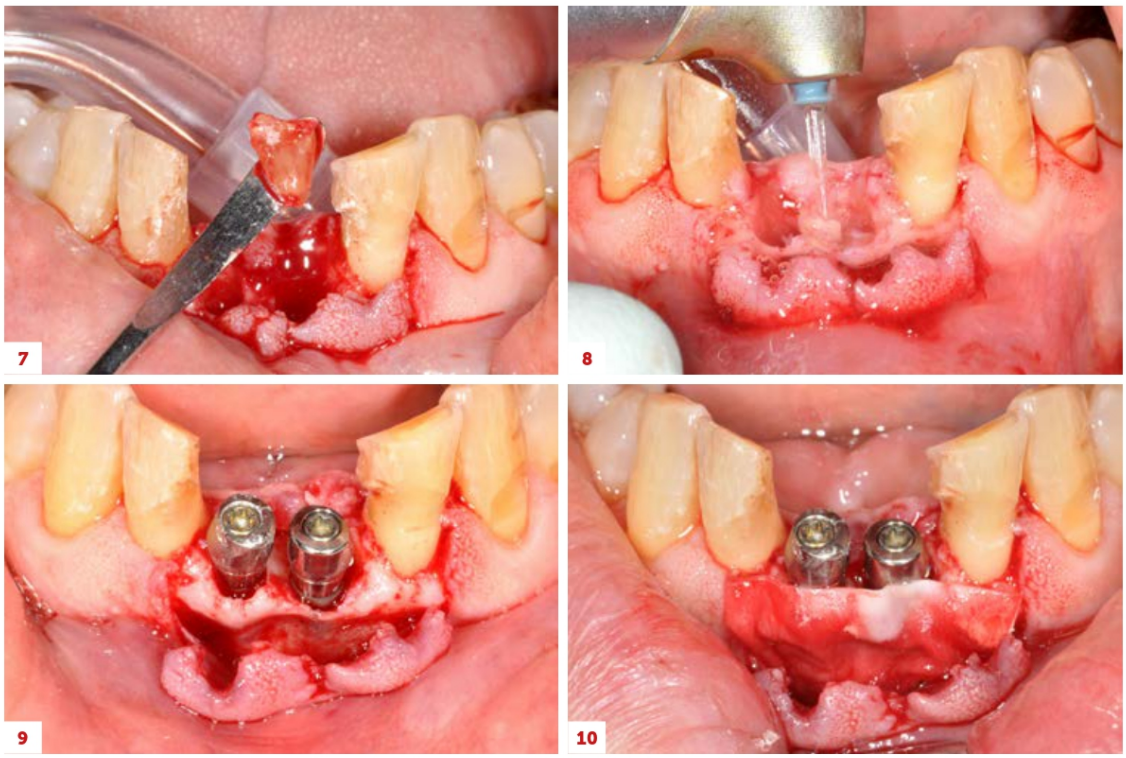






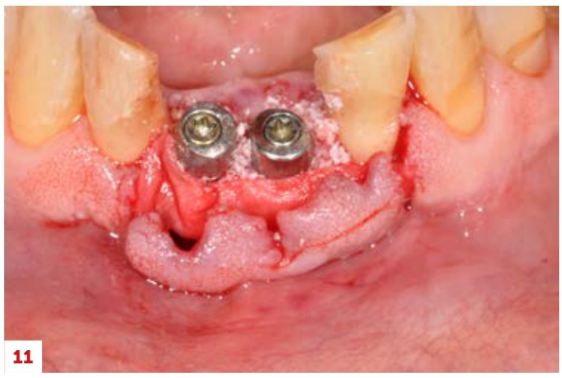
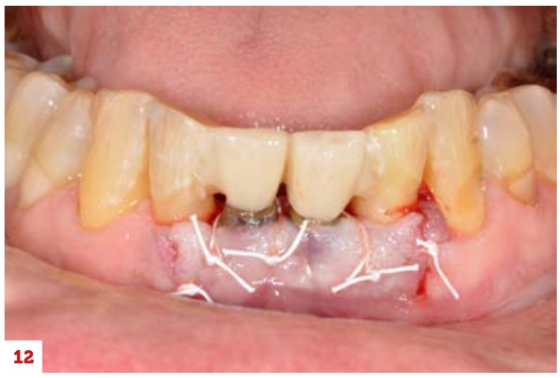
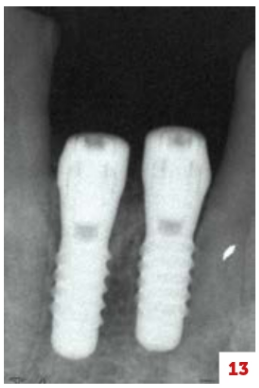
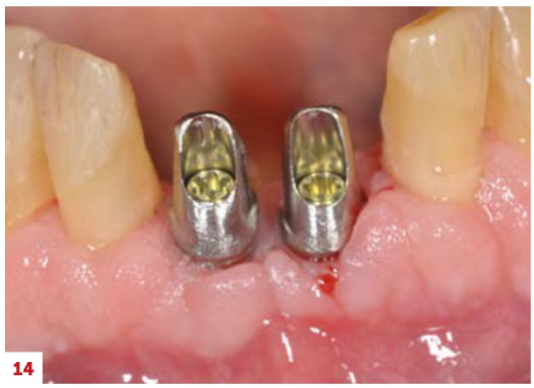
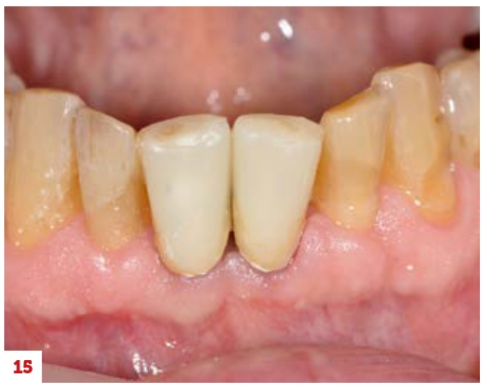
CASO CLINICO

Il caso clinico concerne un paziente uomo di 56 anni in buono stato di salute generale, di cui l'esame clinico, il sondaggio parodontale e le radiografie hanno suggerito la presenza di una frattura radicolare dell'elemento 3.1 e la mobilità del 4.1 (Figure 1, 2). Il piano di trattamento è stato concordato dopo un'attenta analisi che ha escluso la presenza di controindicazioni, come scarsa igiene orale o fumo. Il paziente ha acconsentito a un piano di trattamento che prevedeva l'estrazione del dente fratturato e di quello mobile, la decontaminazione del sito utilizzando il laser Er,Cr:YSGG 2.780nm, il posizionamento di due impianti nella stessa seduta



7. Estrazione del moncone radicolare residuo
8. Decontaminazione laser del sito post-estrattivo con modalità hard tissue
9. Inserimento delle fixture in zona 3.1 e 4.1
10. Inserimento della membrana in collagene

clinica, e ha fornito il suo consenso informato per lo studio. Il paziente ha iniziato la terapia antibiotica (amoxicillina, 1 g ogni 12 ore per 6 giorni) la sera prima dell'intervento. Come anestetico locale per l'intervento è stata utilizzata la mepivacaina cloridrato (Optocain® 1: 100.000, Molteni).
Gli elementi 3.1 e 4.1 sono stati estratti in modo atraumatico per salvaguardare i tessuti periradicolari, con l'ausilio del laser Er,Cr:YSGG 2.780nm (Figure 3-7).
È stato allestito un lembo a tutto spessore utilizzando il laser con le seguenti impostazioni: configurazione per la modalità tessuti molli (S mode), che includeva la tip in zaffiro MC-3 di lunghezza 9 mm, aria 20% e acqua 80%, potenza di 3.5 W e frequenza di 50 Hz.
Per il tessuto osseo è stato eseguito un debridement, l'impostazione del settaggio era: configurazione tessuti duri (hard mode), tip in zaffiro MZ-8 (lunghezza 6 mm), aria 40% e acqua 60%, potenza 4.0 W con frequenza di 20 Hz.
Una volta completata l'estrazione dei due elementi e rimosso il residuo radicolare del 3.1, è iniziata la fase di decontaminazione del sito infetto.
Il tempo di debridement è dipeso dalla quantità di tessuto patologico e dal volume osseo, mentre la decontaminazione ha avuto una durata dai 60 ai 90 secondi per sito, garantendo l'assenza di contatto fisico tra la punta e i tessuti con un volume d'acqua di circa 100 ml al minuto (wash-out massimo).
Il dispositivo Waterlase iPlus® (Biolase) è stato utilizzato per tutte le procedure laser.
Per il sito post-estrattivo, la decontaminazione è stata effettuata utilizzando lo stesso dispositivo laser, ma con un'altra impostazione: configurazione tessuti duri (hard mode), potenza 2,0 W e frequenza di 20 Hz, 20% di aria e 80% di acqua, utilizzazione di tip MZ-6 (9 mm di lunghezza) (Figura 8).
Le fasi successive dell'intervento hanno previsto il posizionamento di due impianti (Straumann).
Le fixture (SLActive® S, Ø 3.3 mm, RN, lunghezza 8 mm per sostituire il dente 3.1 e il dente 4.1) sono state posizionate con un torque minimo di 35 N e 1 mm al di sotto del picco osseo più

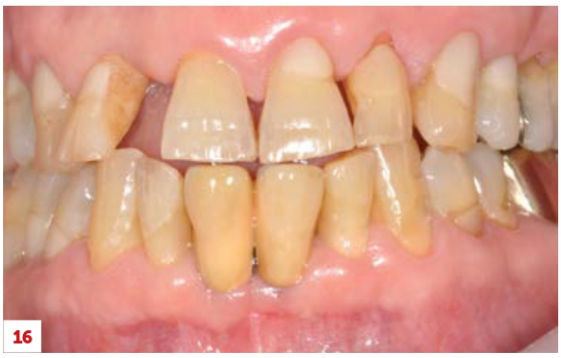






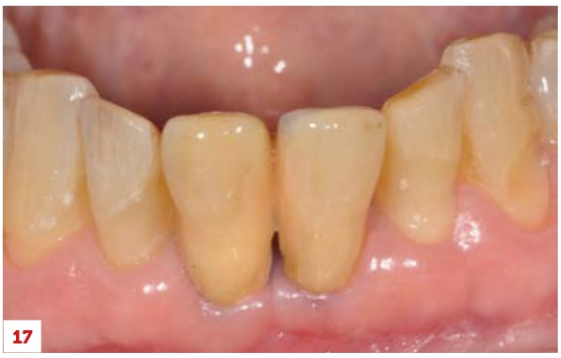
apicale (Figura 9). Inoltre, è stato necessario ricorrere all'utilizzo di alcuni biomateriali per colmare il difetto residuo causato dall'infezione: sono stati utilizzati collagene (Hemocollagene, Septodont) e una membrana riassorbibile (Collprotect®, Straumann) per migliorare la guarigione dei tessuti (Figure 10, 11).
Le suture (PTFE 3/0 Gore®) sono state posizionate con particolare cura per ottenere un buon riposizionamento del lembo (Figura 12) ed è stata eseguita una rx endorale finale (Figura 13).
La fase protesica provvisoria prima del carico è stata gestita con un ponte di Maryland in resina (Figure 14, 15).
Contestualmente è stato prescritto gel di clorexidina gluconato allo 0,2% due volte al giorno per 5 minuti minimo, per 15-20 giorni e al paziente sono state fornite istruzioni post-operatorie. Sono stati programmati controlli clinici e radiografici periodici a 1, 4, 8 e 12 mesi per il primo anno e gli impianti sono stati caricati dopo 3 mesi (Figure 16-18).

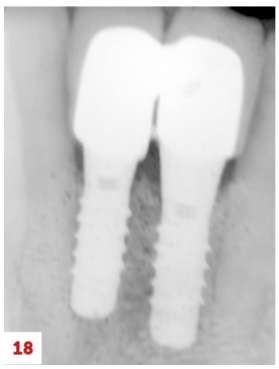
RISULTATI

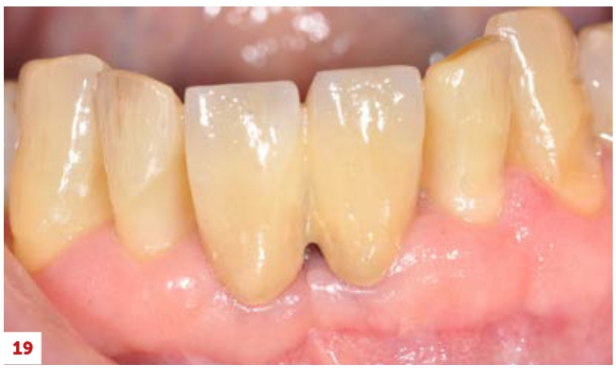
La riabilitazione protesica dopo la fase chirurgica ha permesso di fornire una corretta funzionalità e un'estetica soddisfacente. Nella visita di follow-up, è stata riscontrata una buona guarigione dei tessuti e l'assenza di complicanze cliniche, come mucositi o perimplantiti. Gli impianti hanno raggiunto una buona stabilità primaria (> 35 N/ cm) e il carico è stato eseguito dopo 3 mesi posizionando su entrambe le fixture dei monconi angolati di 20° e, contestualmente, due elementi provvisori in resina. I provvisori sono rimasti in sede per 4 mesi, dopodiché si è proceduto, visto l'ottimo andamento della rigenerazione ossea, alla protesizzazione finale con corone in metallo-ceramica (Figura 19). Il successo della terapia implantare è evidenziato dai controlli clinici e radiografici. La tecnica utilizzata nel nostro studio è ripetibile e prevedibile, e questo caso ne descrive i passaggi salienti; la selezione dei candidati, tuttavia, è molto importante per il successo di questo protocollo, in quanto la presenza di controindicazioni può portare al fallimento.

11. Riempimento del gap residuo con sostituto osseo
12. Sutura in materiale riassorbibile
13. Radiografia postoperatoria
14. Abutment implantari
15. Elementi provvisori in resina









16. Elementi provvisori in porcellana
17. Dettaglio degli elementi provvisori
18. Radiografia di controllo a 5 anni
19. Follow-up a 5 anni

DISCUSSIONE

Il concetto di inserimento immediato di impianti dopo l'avulsione di denti compromessi per diversi fattori eziologici è ancora oggi materia di dibattito. Anche se questa tecnica riduce al minimo il numero di procedure chirurgiche combinando l'estrazione, l'inserimento dell'impianto e la rigenerazione tessutale in un'unica seduta, c'è un potenziale rischio di contaminazione durante la fase iniziale di guarigione rappresentato da un possibile persistere dei residui della lesione apicale[9].

Studi clinici condotti sugli esseri umani hanno suggerito che una storia di infezioni parodontali ricorrenti può essere un marker predittivo di infezione e di fallimento dell'impianto. Questo dato ha portato la maggior parte dei clinici a evitare l'inserimento immediato di impianti endossei in siti infetti e a considerare l'infezione una possibile controindicazione per l'impianto immediato. Tuttavia, i risultati di diversi autori e i nostri[10,11], suggeriscono che gli impianti immediati possono essere introdotti con successo nel trattamento di siti alveolari infetti sotto una procedura controllata[12,13].

L'effetto fotoacustico esercitato dal laser Er,Cr:YSGG 2.780nm si è dimostrato efficace contro molti patogeni: recenti studi hanno evidenziato, infatti, come la tecnologia laser sia capace di eliminare i batteri più efficacemente dei prodotti chimici. Inoltre, l'utilizzo di questa tecnica consentirebbe sia al paziente che al clinico di beneficiare di un tempo di trattamento ridotto[6]. L'efficacia del laser Er,Cr:YSGG 2.780nm nella disinfezione del sito chirurgico dipende dall'effetto fotoacustico della radiazione laser, che attacca le colonie batteriche[14,15]; questo effetto è stato ampiamente studiato in vitro, attraverso esperimenti che ne hanno dimostrato la validità[16,17]. Un fattore importante è l'impostazione dei parametri del laser: la potenza e la frequenza devono essere regolate per garantire una disinfezione ottimale del sito senza rischiare danni ai tessuti circostanti[18].

Anche l'esperienza dell'operatore, inoltre, con questa tecnica gioca un ruolo fondamentale. L'utilizzo del dispositivo laser per la chirurgia implantare può anche essere vantaggioso per ridurre il sanguinamento intraoperatorio, mantenendo quindi libero il campo operatorio[19,20].

CONCLUSIONI

Entro i limiti di questo studio, possiamo affermare che il posizionamento immediato di un impianto può essere considerato un'opzione di trattamento sicura, efficace e prevedibile per il ripristino degli alveoli postestrattivi infetti e/o infiammati, qualora vengano adottate procedure intraoperatorie appropriate per la toilette chirurgica e la decontaminazione dei siti. Il posizionamento immediato di un impianto in siti postestrattivi infetti e/o infiammati dopo la decontaminazione laser non sembra aumentare il rischio di fallimento, come dimostrato da questo caso e da altri report pubblicati in precedenza, né condurre a un numero maggiore di complicanze rispetto alla tecnica tradizionale.
La tecnica laser offre, inoltre, interessanti vantaggi nel trattare le aree estetiche con impianti postestrattivi e, ove possibile, con protesizzazione immediata. È indispensabile seguire determinati protocolli e procedure cliniche per prevenire il rischio di perimplantite e altre complicanze. Si rendono indubbiamente necessari ulteriori studi per chiarire appieno l'importanza e il meccanismo alla base della tecnica.

ABSTRACT

Questo articolo illustra la tecnica di implantologia immediata associata alla disinfezione laser e presenta un caso clinico di un uomo di 56 anni, con follow-up a 5 anni, per chiarire i passaggi principali per una corretta gestione della procedura. Il laser Er,Cr:YSGG 2.780nm può, infatti, ridurre in modo significativo la concentrazione batterica presente nell'alveolo di un dente estratto. L'inserimento contestuale di impianti post-estrattivi, con la possibilità di riabilitare immediatamente un paziente con edentulia, rappresenta una valida opzione terapeutica e una pratica oggigiorno comune in chirurgia orale, grazie anche all'elevata percentuale di successo e ai suoi numerosi vantaggi; tra questi si evidenziano il mantenimento delle dimensioni verticale e orizzontale del tessuto osseo, il dimezzamento dei tempi di trattamento, l'aumento in termini di comfort da parte del paziente e i soddisfacenti risultati estetici.

This article illustrates the immediate implant placement technique associated with laser disinfection. We report a clinical case, with 5-year follow-up, to elucidate the main steps for correct management of the procedure. The Er, Cr: YSGG 2.780nm laser, indeed, can significantly reduce the bacterial concentration present in the alveolus of an extracted tooth. Nowadays, the concurrent insertion of post-extraction implants, with the possibility of immediate post surgery rehabilitation of the edentulous patient, constitutes a valid therapeutic option and a common practice in oral surgery. Among the advantages of this technique, there are the maintenance of the vertical and horizontal dimensions of the bone tissue, the halving of treatment times, the increase in patient comfort, and satisfactory aesthetic results.

BIBLIOGRAFIA

1. Chang SW, Shin SY, Hong JR, et al. Immediate implant placement into infected and noninfected extraction sockets: a pilot study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009 Feb; 107(2):197-203.
2. Lazzara RJ. Immediate implant placement into extraction sites: surgical and restorative advantages. Int J Periodontics Restorative Dent 1989; 9(5):332-43.
3. Diz P, Scully C, Sanz M. Dental implants in the medically compromised patient. J Dent 2013 Mar; 41, 3:195–206.
4. Lindeboom JA, Tjiook Y, Kroon FH. Immediate placement of implants in periapical infected sites: a prospective randomized study in 50 patients. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006 Jun; 101(6):705-10.
5. Siegenthaler DW, Jung RE, Holderegger C, et al. Replacement of teeth exhibiting periapical pathology by immediate implants: a prospective, controlled clinical trial. Clin Oral Implants Res 2007 Dec; 18(6):727-37.
6. Kusek ER. Immediate implant placement into infected sites: bacterial studies of the Hydroacoustic effects of the YSGG laser. J Oral Implantol 2011 Mar; 37 Spec No():205-11.
7. Montoya-Salazar V, Castillo-Oyagüe R, Torres-Sánchez C, et al. Outcome of single immediate implants placed in post-extraction infected and non-infected sites, restored with cemented crowns: a 3-year prospective study. J Dent 2014 Jun; 42(6):645-52.
8. Marconcini S, Barone A, Gelpi F, Briguglio F, Covani U. Immediate implant placement in infected sites: a case series. J Periodontol 2013 Feb; 84(2):196-202.
9. Lindeboom JA, Tjiook Y, Kroon FH. Immediate placement of implants in periapical infected sites: a prospective randomized study in 50 patients. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006;101:705–10.
10. Crippa R, Aiuto R, Dioguardi M, et al. Laser therapy for infected sites and immediate dental implants in the esthetic zone: a case report and review of literature. Case Rep Dent 2020 Jan 7;2020:2328398. doi: 10.1155/2020/2328398.
11. Crippa R, Aiuto R, Guardincerri M, et al. Effect of laser radiation on infected sites for the immediate placement of dental implants. Photobiomodul Photomed Laser Surg 2020 Mar;38(3):186-192. doi: 10.1089/photob.2019.4636.
12. Karoussis IK, Salvi GE, Heitz-Mayfield LJ, et al. Long-term implant prognosis in patients with and without a history of chronic periodontitis: a 10-year prospective cohort study of the ITI Dental Implant System. Clinical Oral Implants Research 2003;14:329–39.
13. Casap N, Zeltser C, Wexler A, et al. Immediate placement of dental implants into debrided infected dentoalveolar sockets. J Oral Maxillofac Surg 2007;65:384–92.
14. Licata ME, Albanese A, Campisi G, et al. Effectiveness of a new method of disinfecting the root canal, using Er-Cr:YSGG laser to kill Enterococcus faecalis in an infected tooth model. Lasers Med Sci 2015 Feb; 30(2):707-12.
15. Schoop U, Kluger W, Moritz A, et al. Bactericidal effect of different laser systems in the deep layers of dentin. Lasers Surg Med. 2004; 35(2):111-6.
16. Moritz A, Doertbudak O, Gutknecht N, et al. Nd:YAG laser irradiation of infected root canals in combination with microbiological examinations. J Am Dent Assoc 1997 Nov; 128(11):1525-30.
17. Gordon W, Atabakhsh VA, Meza F, et al. The antimicrobial efficacy of the erbium, chromium:yttrium-scandium-gallium-garnet laser with radial emitting tips on root canal dentin walls infected with Enterococcus faecalis. J Am Dent Assoc 2007 Jul; 138(7):992-1002.
18. Zhu L, Tolba M, Arola D, et al. Evaluation of effectiveness of Er,Cr:YSGG laser for root canal disinfection: theoretical simulation of temperature elevations in root dentin. J Biomech Eng. 2009 Jul; 131(7):071004.
19. Crespi R, Capparè P, Gherlone E. Fresh-socket implants in periapical infected sites in humans. J Periodontol 2010 Mar; 81(3):378-83.
20. Kakar A, Kakar K, Leventis MD, Jain G. Immediate implant placement in infected sockets: a consecutive cohort study. J Lasers Med Sci 2020 Spring;11(2):167-173. doi: 10.34172/jlms.2020.28.

Odontology

Immediate dental implant placement in post-extraction-infected sites decontaminated with Er,Cr:YSGG laser: a retrospective cohort study

--Manuscript Draft--

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Abstract:	The placement of dental implants into fresh extraction sockets offers some advantages, including reduced treatment times and enhanced patient comfort. The Er,Cr:YSGG laser can significantly reduce the bacterial concentration after compromised tooth extraction. The objective of this controlled study conducted after at least 1 year of follow-up was to compare the use of immediate post-extraction implants in infected sites treated with laser (test group) versus conventional implants in edentulous sites (control group) through an analysis of pre- and postoperative radiographs. The study was based on a series of patients treated between 2014 and 2019, with a minimum follow-up of 1 year, and up to over 4 years. An analysis of the clinical history of the treated patients and pre- and postoperative radiographs was performed to evaluate the implant success and to measure the marginal bone level (MBL). Overall, 149 implants were studied. There was only one failure in the test group (1%) and no failures in the control group. The test group gained 0.1 mm of the MBL compared to the baseline while the control group lost 0.1 mm of the MBL. The difference between the two groups of only 0.2 mm was not statistically significant (P = 0.058). Immediate dental implants in infected sockets debrided and decontaminated using Er,Cr:YSGG laser do not appear to enhance the likelihood of failure; however, peri-implantitis and associated problems must be avoided by following a certain set of protocols and procedures.
Response to Reviewers:	Dear Editor, Dear Reviewers,

	Following your kind instructions, we have made a series of changes (visible in the text with the blue color) in order to reduce the similarity index. The revision of the sentences did not alter their content. Thank you very much. With regard, Riccardo Aiuto
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Question	**Response**
Is a statistical analysis included? For papers that include original statistical analysis, it is strongly recommended that a statistician review the methodology and be listed as an author of the manuscript. Alternatively, the statistician should be acknowledged at the end of the manuscript.	Yes, and the manuscript complies with the Instructions for Authors.
Please indicate the total word count of the article. Use the Word Count function in Microsoft Word to calculate the number of words. 	5733

Immediate dental implant placement in post-extraction-infected sites decontaminated with Er,Cr:YSGG laser: a retrospective cohort study

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ABSTRACT

Dental implants placed in fresh extraction alveoli provide several advantages, including shorter treatment periods and improved patient comfort. After a compromised tooth extraction, the Er,Cr:YSGG laser can considerably reduce bacterial concentration. The objective of this controlled study conducted after at least 1 year of follow-up was to compare the use of immediate post-extraction implants in infected sites treated with laser (test group) versus conventional implants in edentulous sites (control group) through an analysis of pre- and postoperative radiographs. The study was based on a series of patients treated between 2014 and 2019, with a one-year minimum follow-up, and up to over 4 years. An analysis of the clinical history of the treated patients and pre- and postoperative radiographs was performed to evaluate the implant success and to measure the marginal bone level (MBL). Overall, 149 implants were studied. There was only one failure in the test group (1%) and no failures in the control group. The test group gained 0.1 mm of the MBL compared to the baseline while the control group lost 0.1 mm of the MBL. The difference between the two groups of only 0.2 mm was not statistically significant (P = 0.058). Immediate dental implants in infected sockets debrided and decontaminated using Er,Cr:YSGG laser do not appear to enhance the likelihood of failure; however, peri-implantitis and associated problems must be avoided by following a certain set of protocols and procedures.

Key words: dental implant, Er,Cr:YSGG laser treatment, oral surgery, tooth extraction, socket preservation

Introduction

Immediate placement of a dental implant (type 1 placement technique [1]) has become a popular therapeutic choice in recent years. Schulte and Heimke introduced the surgical approach for immediate insertion of a fixture in a fresh alveolar socket in 1976 [2]. This protocol's proponents argue that by limiting the surgical exposure of the patient, bone resorption following dental extraction is decreased [3]. This technique has been effectively used to several forms of implant-prosthetic rehabilitation, and many scientific studies demonstrate its validity [4, 5]. Dental implants inserted in post-extraction sites have several advantages, including decreased treatment time and improved patient comfort [6].

Tooth extraction is frequently associated with an apical infection: one of the main limits to early implant placement is represented by a bacterial contamination of the implant surface during the healing process [7]. Animal studies, on the other hand, have shown that a periapical lesion does not limit the osseointegration of post-extraction fixtures. Furthermore, BIC (bone-to-implant contact) is not affected [8-12]. An increasing number of publications have detailed the feasibility of this dental implant technique also in infected dental alveoli, although dependent on whether the correct indicators are present and if a rigorous decontamination protocol is adhered to [13].

Various methods for decontaminating the post-extraction site prior to implant placement have been described. Marconcini et al. proposed tooth extraction with utmost caution to maintain alveolar bone integrity, as well as delicate curettage of sockets [14]. Besides, antibiotics and chlorhexidine mouth rinses are two strategies for reducing the bacterial load of infected alveoli. Del Fabbro et al. published a similar approach in a cohort study, but with the inclusion of PRGF in infected alveoli [15]. Lasers have also been added to the clinical protocol to obtain thorough decontamination and to limit case failures. Kusek presented the first case series, which included 10 immediate implantation [16]. Later other authors carried out independent research illustrating the use of Er,Cr:YSGG laser to treat dental alveoli [17-19].

The objective of this controlled study, conducted within at least one year of follow-up after treatment was to compare the use of immediate implants (type 1) in post-extraction-infected alveoli debrided and decontaminated with Er,Cr:YSGG laser (test) versus conventional implants in edentulous sites (control) in a sample of treated patients. The primary variable was the difference in MBL (marginal bone level) between the follow-up and baseline (implant placement). The outcome variables included implant failure and complications (such as mucositis or peri-implantitis).

Materials and methods

Study design

This research received the approval of the ethics committee of the University of Valencia (no. 1606937298573) and was performed in strict compliance with the STROBE statement (von Elm et al. 2008). The current study was based on a series of patients treated between 2014 and 2019, with a one-year minimum follow-up, up to over 4 years (the calculation of the sample size was not necessary as all patients were included in the time period indicated). The current study was carried out in collaboration with the Istituto Stomatologico Italiano of Milan (Italy) at the Oral Surgery Department of the University of Valencia (Spain).

The first step of this study included the selection of the x-rays (intraoral periapical radiograph taken with the positioning ring and the parallel technique) and the medical records of the included patients. All participants either received immediate dental implant treatment placed in infected alveoli debrided and decontaminated with lasers or received implants using traditional techniques. Patients must have had a minimum of 1-year follow-up. Other exclusion criteria were as follows: participants with significant systemic disorders, history of radiation therapy, current steroid treatment, neurological or psychiatric problems, immunocompromised status, bruxism, a smoking habit (more than fifteen cigarettes per day), alcohol or drug use, and poor compliance.

The second step of this study included the measurement of digital radiographs by a blinded operator (R.A.) with a specific software (Image J, National Institute of Health, Bethesda, Rockville, MA, USA). The following parameters were used for radiographs: 65-90 kV, 7.5-10 mA and 0.22-0,25 s. Each periapical x-ray was calibrated prior to examination by considering the parameters of the fixture (diameter and length) as reference values to adjust for any distortion. The radiographs were measured on a medical screen with a resolution of 1920 × 1080 and with magnification of 7x). Marginal bone level was quantified at baseline and follow-up according to Linkevicius et al. The segment between the fixture neck and the first bone-to-implant contact was calculated and taking into consideration both the mesial and distal parts of each fixture (Fig. 1).

An intra-rater agreement was performed for the radiographic evaluation. An a-priori independent sample of 20 fixture surfaces was assessed twice, two weeks apart. For radiographic intra-examiner agreement test, the two-way intra-class correlation coefficient was 0.97 (95% CI).

Statistical analysis

As descriptive statistics, the mean and standard deviation of the quantitative variables, as well as the frequency and percentages of the qualitative variables, were utilized. The implant was the subject of analysis; accounting for the fact that multiple implants were often used for each patient.

A mixed statistical model was used for the outcome variable difference in MBL using the patient as a random effect. The covariate was the MBL at baseline, and the group (test or control implant) was the explanatory variable (fixed effect).

To compare the contrast at baseline between the two groups (test implants versus control implants), mixed effects models were used for the quantitative variables including age, implant length, implant diameter, and MBL at baseline. A mixed effects model was also used to compare the duration before a follow-up between the two groups. The participant was the random effect (random effect), and the group (implant test or control) was the explanatory variable (fixed effect).

In order to compare the differences at baseline between the two groups, multilevel models were used for the qualitative variables: sex, smoking, arch (upper or lower), area (frontal - incisors or canines - or posterior -premolar or molar-), extraction reasons (fracture vs. other), presence of abscess or fistula, presence of lesion, implants with narrow neck, immediate loading, use of membrane, use of collagen, and use of synthetic bone. The models were constructed at two levels (patient and implant), and the group (test implant or control) was the explanatory variable. The significance level was set at $P < 0.05$; statistical analysis was carried out using JMP v. 13.0, and MLwin v. 3.05.

Surgical phase

All patients consented to a therapeutic plan including the dental extraction, debrided and decontamination of the alveoli using the Er,Cr:YSGG 2780 nm laser (for all surgical phases), and insertion of a fixture in the same appointment, to replace the extracted tooth (test group). The treatment plan was decided following a thorough examination that ruled out any contraindications. The patients provided informed consent for data processing.

The surgical phase (Figs. 2 and 3) included antibiotic prophylaxis that started the night before intervention. The local anesthetic administered in the interventions was Optocain®. The compromised teeth were extracted atraumatically to conserve the remaining tissues. The flap was performed by the laser with specific parameters: settings for the soft tissue mode (s), which included an MC-3 tip at a length of 9 mm, including 20% air and 80% water. The tip was in contact with the tissue, simulating the action of the scalpel (chisel tip), and it was used with soft tissue parameters. Once the extraction was carried out, the debridement phase of the infected alveolus has begun.

For bone tissue, the parameters included an MZ-8 tip at a length of 6 mm, including 40% air and 60% water. The site was decontaminated with the hard tissue mode (H), 2.0 W, 20% air, and 80% water, while mounting a 9 mm MZ-6 tip. In order to reach the apex of the dental socket more easily, the tip was changed again; during the decontamination phase the tip was not in contact but approached the bone 1-2mm approximately. The laser was the only tool used to remove infected tissue (Fig. 4). Debridement time was determined by the bone volume and amount of pathological tissue (it is a mechanical action performed exclusively with the laser), while decontamination lasted from 60 to 90 seconds per alveolus (wash out H2O 100ml/min), without contact between the tip of the laser and the bone (it is a bactericidal action that exploits the photoacoustic effect of the laser). All laser treatments were performed with the Waterlase iPlus® (Biolase) equipment.

The following phases of the surgery included the placement of the implants (Straumann®). Often, it is also essential to put in place biomaterials for the infection-related residual defects. Collagen (Septodont®) and an absorbable membrane (Collprotect®) were applied in order to promote tissue repair. Sutures were carefully inserted to provide optimal flap repositioning. Subsequently, 0.2% chlorhexidine gluconate gel was prescribed for two weeks, and postoperative instructions were illustrated to the patient. The fixtures were either loaded immediately or after 3 months.

Patients in the control group followed a similar implant protocol, but tooth extraction had taken place at least 3 months earlier. There was no laser debridement/decontamination of the site.

Results

Overall, 98 patients aged 58.0 ± 14.6 years (21 to 88 years), 52 females (53%) and 46 males (47%), 22 smokers (22%) were treated. Of which, 149 implants were placed for 90 (60%) test subjects and 59 (40%) control subjects.

Test implants were placed in 53 patients (one fixture was inserted in 35 patients, two simultaneous implants were inserted in 10 patients, three simultaneous implants in four patients, four simultaneous implants in three participants, and five simultaneous implants in one patient). Control implants were placed in 39 patients (one fixture was inserted in 29 patients, two simultaneous implants were inserted in seven patients, three simultaneous implants in three patients). Both experimental and control implants were inserted in six patients (one test implant and one control implant in five patients, one test implant and two control implants in one patient).

Baseline

Patient-related variables at baseline are shown in Table 1. The table refers to patients who had at least one implant of either type. The variables related to the site are listed in Table 2.

Table 1. Patient-related baseline characteristics

Variable	Test group *N*=59	Control group *N*=45	P-value
Sex (female) (%)	29 (49%)	25 (56%)	0.764*
Sex (male) (%)	30 (51%)	20 (44%)	0.764*
Age (years) (SD)	59.3 (14.5)	57.5 (14.5)	0.977**
Smoker (%)	13 (22%)	9 (20%)	0.913*

SD: standard deviation. * Multilevel model; ** Mixed model.

Table 2. Baseline characteristics related to the implant

Variable	Test group *N*=90	Control group *N*=59	P-value
Upper arch	47 (52%)	25 (42%)	0.279*
Lower arch	43 (48%)	34 (58%)	0.279*
Zone (anterior)	26 (29%)	9 (15%)	0.201*
Zone (posterior)	64 (71%)	50 (85%)	0.201*
Extraction (fracture)	43 (48%)	31 (52%)	0.987*
Extraction (no fracture)	47 (52%)	28 (48%)	0.987*
Abscess or fistula	61 (68%)	42 (72%)	0.866*
Lesion	20 (22%)	2 (3%)	**0.007***
Narrow neck	12 (13%)	10 (17%)	0.563*
Implant length, mm (SD)	9.9 (1.7)	8.9 (1.7)	**0.001****
Implant diameter, mm (SD)	3.9 (0.4)	4.0 (0.5)	0.232**
Immediate loading	21 (23%)	8 (14%)	0.534*
Membrane	69 (77%)	30 (51%)	**0.047***
Collagen	21 (23%)	22 (37%)	0.324*
Synthetic bone	55 (61%)	18 (31%)	**0.011***
MBL baseline mm (SD)	2.4 (1.3)	2.4 (0.8)	0.912**

SD: standard deviation. * Multilevel model; ** Mixed model.

In the test group, lesions were more common. Additionally, if the implant length was greater than 1 mm, the membrane and synthetic bone were more frequently used. The reasons for extraction in the test group included: caries 32 (36%), endodontic 10 (11%), fracture 43 (48%) and periodontal 5 (6%); and in the control group: caries 20 (34%), endodontic 1 (2%), fracture 31 (52%) and periodontal 7 (12%).

The implants were all Straumann implants. In the test group, TE RN Loxim SLA Roxolid 33 (37%), S RN Loxim SLA Roxolid 37 (41%), SP RN Loxim SLA TiZr 4 (4%), SP NNC SLAactive TiZr 3 (3%), S RN SLAactive Roxolid 4 (4%), and SP NNC Loxim SLA Roxolid 9 (10%). In the control group, TE RN Loxim SLA Roxolid 6 (10%), S RN Loxim SLA Roxolid 39 (66%), SP RN Loxim SLA TiZr 4 (7%), SP NNC SLAactive TiZr 0 (0%), S RN SLAactive Roxolid 0 (0%), and SP NNC Loxim SLA Roxolid 10 (17%).

Follow-up

The follow-up was carried out after 1.7 ± 0.6 years in the experimental group and 1.5 ± 0.5 years in the control group, with a non-statistically significant difference (P = 0.082; Mixed model). There was only one failure in the test group (1%) and no failure in the control group. There was only one complication (mucositis) in the control group (2%) and no complications other than failure in the test group. MBL results at follow-up are shown in Table 3.

Table 3. Marginal bone level (MBL) at follow-up

Variable	Group Test *N*=89	Group Control *N*=59	Diff	95%CI	*P*-value
MBL at follow-up, mm (sd)	2.3 (0.9)	2.5 (0.7)	0.2	0.0; 0.4	0.058*
MBL difference between baseline and follow-up, mm (SD)	0.1 (1.0)	-0.1 (0.6)	0.2	0.0; 0.4	0.058*

SD: standard deviation. * Mixed model

The difference in MBL between the two groups was in favor of the experimental group which gained 0.1 mm relevant to the baseline while the control group lost 0.1 mm of MBL. However, the difference between the two groups was only 0.2 mm, which was not statistically significant (P = 0.058).

Discussion

From the results, the two groups appeared sufficiently homogeneous in terms of patient's age and gender and the areas treated, making the comparison of this retrospective study more reliable. Surgical options, such as implant length or the use of biomaterials, often vary according to the clinical situation. For example, in the test group, the implants were longer. In addition, membranes and autologous bones were used more often in the test group since lesions were detected more often, and thus, bone defects were treated more frequently.

The main objective of this research was to compare post-extraction implants in infected sites to the traditional technique, where fixtures were placed at least 3 months after extraction and without signs of residual infections in the alveoli. The results indicated that there was no difference in MBL between the two groups. Since it is not always easy to identify the presence of an active infection when it is necessary to remove a compromised tooth, type 4 implants were chosen for the control group. They were positioned in edentulous areas with good healing of the post-extraction socket. Therefore, in this situation, we can be sure that surgery was performed in an edentulous area free of bacteria.

This study analyzed 149 implants in total, with mesial and distal MBL measurements at baseline and follow-up. To the best of our knowledge, this is the only controlled study in the literature on implant insertion in infected alveoli debrided and decontaminated with the Er,Cr:YSGG 2780 nm laser. In a recent meta-analysis, Lee et al. showed the same encouraging conclusion by analyzing five prospective studies that did not involve the use of laser but more conventional debridement techniques; the same authors reported the absence of RCTs on the topic in the literature [20].

In a recent publication by Kakar et al., the authors followed a clinical protocol similar to the present study, including debridement with Er,Cr:YSGG 2780 nm laser, to treat a case series without a control group [19]. However, despite the lack of measurements of the MBL, the highlight of the study was that the survival of the implants exceeded 95%, which is in line with the survival rate expected from conventional implantology methods.

Evaluating the success of implant therapy, it is important to calculate the MBL, of which up to 2 mm can be considered as physiologic bone remodeling [21]. The data obtained on the MBL in this research are not only in line with or lower than our control group, but it is also comparable to that of other studies. Among these, Berberi et al. described the MBL in immediate and delayed loading techniques of post-extraction implants [22]; immediate loading seems to guarantee promising clinical results, as shown by several cases in this study.

Previous research comparing panoramic and periapical radiographs found that the latter is deemed the “gold standard” for detecting implants’ MBL [23,24]. CBCT would also be useful, but due to the dose of rays and lack of justification, it would not be possible to find a sufficient number of patients for the study. The need to have comparable radiographs has led to a scrupulous selection of patients to increase the reliability of the data. This could be a limitation of the present study. Another limitation of this work was the modest number of implants losses, making the random-effects logistic regression analysis unmeaningful, and hence, the potential predictors recorded herein could not be related to early or late fixture loss. Furthermore, it is a retrospective study, which implies the presence of some bias, albeit with a protocol already published in previous studies by the same authors [18].

Candidate selection is crucial to the protocol's effectiveness. Some rules, in the authors' opinion, must be followed. Firstly, the patient must be in good health, possibly a nonsmoker, and not have untreated periodontal disease. The candidate must be cooperative and follow the dentist's indications. Seconds, the clinical situation should be meticulously evaluated in advance, including the reason for tooth extraction, the occurrence of recurrent infections, and the kind of bone. As a result, radiographs and, if

applicable, CBCT must be evaluated. Third, surgical prophylaxis, which includes antibiotic medication and 0.2 percent chlorhexidine gel, must be provided. Fourth, in order to preserve the leftover bone, the extraction must be conducted atraumatically. Fifth, among the different types of lasers, Er,Cr:YSGG is indicated for the good decontamination capacity without overheating the surrounding bone. [25]. Lastly, the application of biomaterials is frequently required to deal with bone defects and must be included.

The laser was introduced into dental practice by Leon Goldman in 1964. The erbium wavelengths in mid-IR spectrum have high affinity for HA (hydroxyapatite) and water. Because of the high affinity for water, the penetration depth is minimal, allowing for good surface ablation without harming the deep tissues. Erbium lasers may cut soft tissues and bone with minimum heat damage, in favor of less inflammatory reactions and faster recovery [26]. The use of Er,Cr:YSGG lasers in dental practice has been widely researched and applied in a variety of applications. Their application as an adjuvant to standard periodontal therapy, for example, has been shown to be successful in bacterial reduction. Furthermore, as demonstrated by Dereci et al., Er,Cr:YSGG lasers are effective in the coagulation of opening blood vessels and the de-epithelization of the gingival pocket [27]; however, in these cases the hemostatic action is mainly due to the surgical toilet and the removal of the granulation tissue with the laser. ER,Cr:YSGG lasers have also been shown to improve cell adhesion and migration on root surfaces [28]. The Er,Cr:YSGG laser has been shown to be a useful tool in endodontic therapy: Martins et al. proved that a laser-assisted approach, thanks to the photoacoustic effect, is efficient against a wide range of pathogens [29].

Regardless of the demonstrated laser decontamination action, multiple investigations have shown that if specific safeguards are performed, immediate implants can also be inserted in contaminated sites. Waasdorp et al. confirmed in a comprehensive study that sites must be extensively debrided before to placement, and GBR is typically conducted to cover the gaps between the implant and socket [30]. This dental implant procedure, definitely, has a learning curve and necessitates prior implantology experience. There are some drawbacks, such as the device's price. A review of the trials on the topic shows that immediate dental implants into contaminated sites does not raise the rate of problems or impede tissue integration, as long as correct clinical protocols are followed to obtain a good alveolus cleaning [31].

Plaque accumulation is the primary cause of periodontitis, and the progression from periodontitis to peri-implantitis happens in the absence of supporting maintenance therapy [32]. Preoperative antibiotic usage reduces implant failures, according to Dent et al. [33]. Nonetheless, a systematic review concludes that the advantages of antibiotic administration for non-infected alveoli are uncertain and may be unnecessary [34,35]. It is also crucial to note that the existence of some systemic conditions or dangerous

habits (i.e., smoking) and local risk factors (i.e., presence of keratinized tissue or type of implant surface) may enhance the risk of peri-implantitis [36].

In this implant placement protocol, the authors followed current surgical protocols that include antibiotic prophylaxis, also to prevent systemic superinfections such as bacterial endocarditis, and chlorhexidine in the post-operative period. Consequently, it is not possible to establish a clear causal effect of the laser alone on decontamination and implant success. In any case, the aim of the work is to show the clinical and radiographic success of fixtures placed in infected sites, highlighting a percentage of failure comparable to that of the traditional method and a total healing of osteolytic lesions where present. Therefore, further prospective clinical trails, preferably randomized, are needed to enlighten these aspects. For example, a randomized study (RCT), possibly with a split-mouth design, comparing immediate and non-immediate implants placement in infected sites would be helpful to understand the percentage of success of the first technique versus the second one. Regardless, the described technique is based on recent scientific knowledge and clinical practice that encourages dental implant type 1, even in post-extraction-infected alveoli.

It is quite complex to draw conclusions from this study. In fact, as a non-randomized study, it is difficult to establish to what extent the differences obtained in the two groups were due to the therapy or to the presence of patients, sites, and implants with different characteristics in the two groups. Implants were longer in the test group. In addition, membranes and autologous bones were used more often in the test group. However, the result that there is no difference in MBL, which was improved in the test group, seems promising for the clinical application of the described technique for immediate dental implants insertion in infected alveoli. This technique has various advantages, such as a decreased time of the clinical session and a higher patient comfort, and it does not seem to raise the risk of failure, but it is crucial to follow several precautions and certain procedures to prevent complications like peri-implantitis. This is precisely the most significant conclusion, namely the fact of being able to have a less invasive surgery, with shorter clinical and biological times and without an increased risk of losing the implant.

REFERENCES

1. Hammerle CH, Chen ST, Wilson TG. Consensus statements and recommended clinical procedures regarding the placement of implants in extraction sockets. Int J Oral Maxillofac Implants 2004;19 Suppl, 26-28.

2. Schulte W, Heimke G. The Tubinger immediate implant. Quintessenz. 1976;27:17-23.

3. Paolantonio M, Dolci M, Scarano A, d'Archivio D, di Placido G, Tumini V, et al. Immediate implantation in fresh extraction sockets. A controlled clinical and histological study in man. J Periodontol 2001;72:1560-1571.

4. Rodrigo D, Martin C, Sanz M. Biological complications and peri-implant clinical and radiographic changes at immediately placed dental implants. A prospective 5-year cohort study. Clin Oral Implants Res. 2012;23(10):1224-31.

5. Peñarrocha-Diago M, Maestre-Ferrín L, Demarchi CL, Peñarrocha-Oltra D, Peñarrocha-Diago M. Immediate Versus Nonimmediate Placement of Implants for Full-Arch Fixed Restorations: A Preliminary Study. Oral Maxillofac Surg, 69 (1), 154-9.

6. Koh RU, Rudek I, Wang HL. Immediate implant placement: positives and negatives. Implant Dent. 2010;19(2):98-108.

7. Schwartz-Arad D, Chaushu G. The ways and wherefores of immediate placement of implants into fresh extraction sites: a literature review. J Periodontol. 1997;68:915–923.

8. Chang S-W, Shin S-Y, Hong J-R, et al. Immediate implant placement into infected and noninfected extraction sockets: a pilot study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009;107: 197–203.

9. Novaes A Jr, Marcaccini A, Souza S, Taba MJ, Grisi MF. Immediate placement of implants into periodontally infected sites in dogs: a histomorphometric study of bone-implant contact. Int J Oral Maxillofac Implants. 2003;18:391–398.

10. Marcaccini M, Novaes AJ, Souza S, Taba MJ, Grisi MF. Immediate placement of implants into periodontally infected sites in dogs. Part 2: a fluorescence microscopy study. Int J Oral Maxillofac Implants. 2003;18:812–819.

11. Novaes AJ, Papalexiou V, Grisi M, Souza SS, Taba M Jr, Kajiwara JK. Influence of implant microstructure on the osseointe- gration of immediate implants placed in periodontally infected sites. A histomorphometric study in dogs. Clin Oral Implants Res. 2004;15:34–43.

12. Papalexiou V, Novaes A Jr, Grisi M, Souza SS, Taba M Jr, Kajiwara JK. Influence of implant microstructure on the dynamics of bone healing around immediate implants placed into periodontally infected sites. A confocal laser scanning microscopic study. Clin Oral Implants Res. 2004;15:44–53.

13. Corbella S, Taschieri S, Tsesis I, Del Fabbro M. Postextraction implant in sites with endodontic infection as an alternative to endodontic retreatment: a review of literature. J Oral Implantol. 2013;39(3):399-405.

14. Marconcini S, Barone A, Gelpi F, Briguglio F, Covani U. Immediate implant placement in infected sites: a case series. Journal of Periodontology, vol. 84, no. 2, pp. 196–202, 2013.

15. Del Fabbro M, Boggian C, Taschieri S. Immediate implant placement into fresh extraction sites with chronic periapical pathologic features combined with plasma rich in growth factors: preliminary results of a single-cohort study. J Oral Maxillofac Surg. 2009;67:2476–2484.

16. Kusek ER. Immediate implant placement into infected sites: bacterial studies of the Hydroacoustic effects of the YSGG laser. Journal of oral implantology, vol. 37, no. sp1, pp. 205–211, 2011.

17. Montoya-Salazar V, Castillo-Oyagüe R, Torres-Sánchez C, Lynch CD, Gutiérrez-Pérez JL, Torres-Lagares D. Outcome of single immediate implants placed in postextraction infected and non-infected sites, restored with cemented crowns: a 3-year prospective study. Journal of Dentistry, vol. 42, no. 6, pp. 645–652, 2014.

18. Crippa R, Aiuto R, Guardincerri M, Peñarrocha Diago M, Angiero F. Effect of laser radiation on infected sites for the immediate placement of dental implants. Photobiomodulation, photomedicine, and laser surgery, 2019.

19. Kakar A, Kakar K, Leventis MD, Jain G. Immediate implant placement in infected sockets: A consecutive cohort study. J Lasers Med Sci. 2020;11(2):167-173.

20. Lee J, Park D, Koo KT, Seol YJ, Lee YM. Comparison of immediate implant placement in infected and non-infected extraction sockets: a systematic review and meta-analysis. Acta Odontol Scand. 2018 Jul;76(5):338-345.

21. Renvert S, Persson GR, Pirih FQ, Camargo PM. Peri-implant health, peri-implant mucositis, and peri-implantitis: Case definitions and diagnostic considerations. J Periodontol. 2018 Jun;89 Suppl 1:S304-S312.

22. Berberi AN, Tehini GE, Noujeim ZF, Khairallah AA, Abousehlib MN, Salameh ZA. Influence of surgical and prosthetic techniques on marginal bone loss around titanium implants. Part I: immediate loading in fresh extraction sockets. J Prosthodont. 2014 Oct;23(7):521-7.

23. Kühl S, Zürcher S, Zitzmann NU, Filippi A, Payer M, Dagassan-Berndt D. Detection of peri-implant bone defects with different radiographic techniques – a human cadaver study. Clin Oral Implants Res. 2016 May;27(5):529-34.

24. Sirin Y, Horasan S, Yaman D, Basegmez C, Tanyel C, Aral A, Guven K. Detection of crestal radiolucencies around dental implants: An in vitro experimental study. J Oral Maxillofac Surg. 2012 Jul;70(7):1540-50.

25. Verma SK, Maheshwari S, Singh RK, Chaudhari PK. Laser in dentistry: An innovative tool in modern dental practice. Natl J Maxillofac Surg 2012;3:124-32.

26. Matulić N, Bago I, Sušić M, Gjorgievska E, Kotarac Knežević A, Gabrić D. Comparison of Er:YAG and Er,Cr:YSGG Laser in the Treatment of Oral Leukoplakia Lesions Refractory to the Local Retinoid Therapy. Photobiomodul Photomed Laser Surg, 37 (6), 362-368.

27. Dereci O, Hatipoğlu M, Sindel A, Tozoğlu S, Üstün K. The Efficacy of Er,Cr:YSGG Laser Supported Periodontal Therapy on the Reduction of Peridodontal Disease Related Oral Malodor: A Randomized Clinical Study. Head and Face Medicine (2016) 12(1).

28. Hakki SS, Korkusuz P, Berk G, Dundar N, SaglamM, Bozkurt B, et al. Comparison of Er, Cr:YSGG laser and hand instrumentation on the attachment of periodontal ligament fibroblasts to periodontally diseased root surfaces: an in vitro study. J Periodontol. 2010;81:1216–25.

29. Martins M, Carvalho M, Pina-Vaz I, Capelas J, Martins M, Gutknecht N. Outcome of Er,Cr:YSGG laser-assisted treatment of teeth with apical periodontitis: A blind randomized clinical trial. Photomedicine and Laser Surgery (2014) 32(1) 3-9.

30. Waasdorp JA, Evian CI, Mandracchia M. Immediate placement of implants into infected sites: a systematic review of the literature. Journal of Periodontology, vol. 81, no. 6, pp. 801–808, 2010.

31. Crippa R, Aiuto R, Dioguardi M, Peñarrocha-Diago M, Peñarrocha-Diago M, Angiero F. Laser Therapy for Infected Sites and Immediate Dental Implants in the Esthetic Zone: A Case Report and Review of Literature. Case Rep Dent. 2020 Jan 7;2020:2328398.

32. Romeo E, Ghisolfi M, Carmagnola D. Peri-implant Diseases. A Systematic Review of the Literature. Minerva Stomatol. 2004;53(5):215-30.

33. Dent CD, Olson JW, Farish SE, Bellome J, Casino AJ, Morris HF, et al. The influence of preoperative antibiotics on success of endosseous implants up to and including stage II surgery: a study of 2,641 implants. J Oral Maxillofac Surg 1997;55(12 Suppl 5):19–24.

34. Esposito M, Grusovin MG, Talati M, Coulthard P, Oliver R, Worthington HV. Interventions for replacing missing teeth: antibiotics at dental implant placement to prevent complications. Cochrane Database Syst Rev 2008;3:CD004152.

35. Barone A, Marchionni FS, Cinquini C, Panattoni AC, Toti P, Marconcini S, et al. Antibiotic Treatment to Prevent Postextraction Complications: A Monocentric, Randomized Clinical Trial. Preliminary Outcomes. Minerva Stomatol. 2017;66(4):148-156.

36. Rabel A, Kohler SG. Microbiological study on the prognosis of immediate implant and periodontal disease. Mund Kiefer Gesichtschir 2006;10:7–13.

Figure Legends

Fig 1 Example of x-ray measurement for MBL: 8 mm was the length of the implant used for calibration, while 2.3 and 2.2 mm show the mesial and distal MBL measurement, respectively

Fig 2 Preoperative (a, b) and postoperative (c, d) clinical and radiological conditions of a case of the analyzed sample: the fractured teeth 3.1 and 4.1 were replaced with two post-extraction implants (test group)

Fig 3 Some phases of surgery (test group) that include the application of the laser for atraumatic extraction (a) and site disinfection (b), the placement of the fixtures (c) and the use of biomaterials (d)

Fig 4 Laser parameters

Figure 1

Click here to access/download;Figure;FIG. 1.jpg

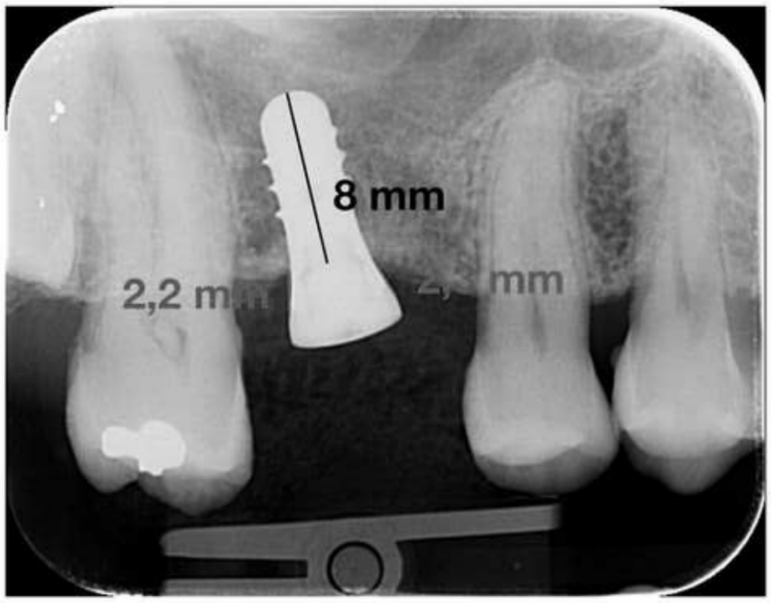

Figure 2

Click here to access/download;Figure;FIG. 2.jpg

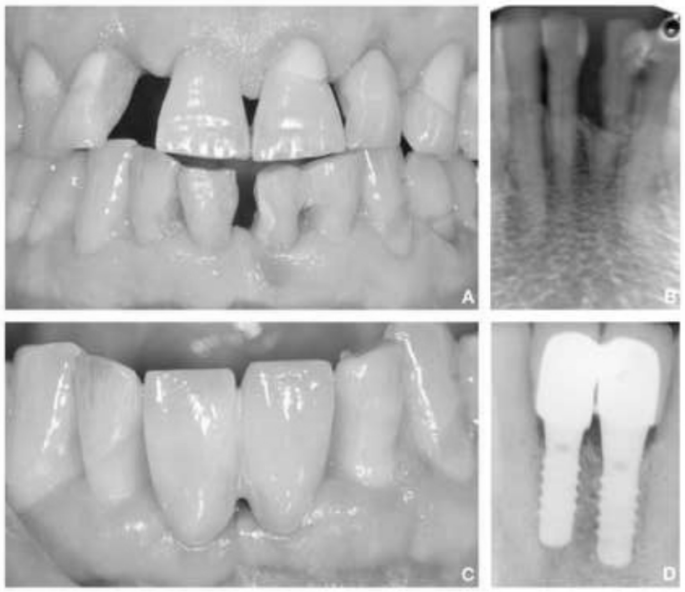

Figure 3

Click here to access/download;Figure;FIG. 3.jpg

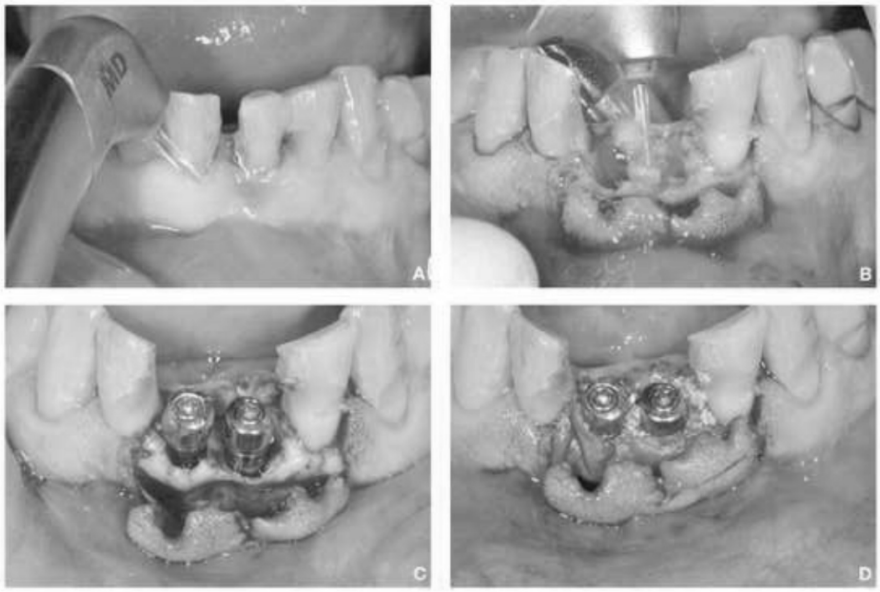

Figure 4

Click here to access/download;Figure;FIG. 4.jpg

Er,Cr:YSGG Laser	TIP	LENGTH	POWER	FREQUENCY	AIR	WATER
INCISION (Soft tissue mode)	MC-3	9 mm	3,5 W	50 Hz	20%	80%
DEBRIDEMENT (Hard tissue mode)	MZ-8	6 mm	3,5 W	20 Hz	40%	60%
DECONTAMINATION (Hard tissue mode)	MZ-6	9 mm	2 W	50 Hz	20%	80%

Date:	08-08-2022
To:	"Riccardo Aiuto" riccardo.aiuto@unimi.it
From:	"Koichi Shinkai" k-shinkai@ngt.ndu.ac.jp
Subject:	ODON: Your manuscript entitled Immediate dental implant placement in post-extraction-infected sites decontaminated with Er,Cr:YSGG laser: a retrospective cohort study

Ref.:
Ms. No. ODON-D-21-00635R2
Immediate dental implant placement in post-extraction-infected sites decontaminated with Er,Cr:YSGG laser: a retrospective cohort study
Odontology

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Koichi Shinkai, Ph.D.
Editor in Chief
Odontology

****

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ENGLISH ABSTRACT

13. ENGLISH ABSTRACT

Scientific background and study aims

The surgical technique for the immediate placement of a dental implant in an extraction socket was initially proposed in 1976 by Schulte and Heimke. The placement of dental implants into fresh extraction sockets offers advantages such as a reduced treatment time and enhanced patient comfort; besides this techniques allows to reduce the patient's surgical exposure and limit the physiological bone resorption after tooth extraction preserving esthetic. The extraction of a compromised tooth is often linked to the presence of a periapical lesion, indicative of an active infection. This is traditionally considered one of the main contraindications to immediate implant insertion because of the increased possibility of the infection spreading to peri-implant tissues during the healing period. However, animal studies have shown that the presence of active periodontal or endodontic infections does not compromise the osseointegration of implants placed at once; additionally, bone-to-implant contact (BIC) is not compromised. After the first in vitro or animal studies, some authors have begun to propose a post-extraction implantology protocol in infected sites also in humans. In a systematic review of the literature, Corbella et al. found nine human studies reporting survival rates ranging between 92% and 100% for a total of 497 implants placed in sites with endodontic infections; the follow-up varied from 3 to 117 months after loading. Different approaches have been proposed for the decontamination of the post-extraction site prior to implant insertion. Measures to decrease the bacterial load of infected sites include mechanical and chemical procedures like meticulous cleaning, alveolar debridement, administration of antibiotics, and postoperative Chlorhexidine 0.12% mouth rinses. Kusek proposed the use of lasers as an adjunct to disinfection procedures, because of laser technology is capable of eliminating bacteria more effectively then chemical products (1000 vs. 100 μm).

The ideal timing of implant placement after dental extraction has been extensively discussed in the literature, and advantages and disadvantages have been attributed to the different protocols, although there is an increasing interest for shortening the overall treatment time and minimizing the number of surgical interventions. The implant type 1 results in shorter treatment time, utilizes all available existing bone in the ridge and may avoid the need for raising a flap. On the other hand, it's possible to have an increased risk of infection (infected alveoli); the presence of a discrepancy between the surface of the implant and the socket wall with a need to combine with bone augmentation techniques; the need to advance the flap to cover the fixtures in situations aiming for a healing by secondary intention; an higher risk for compromised aesthetic outcomes.

In reality, all these drawbacks can also be found with other implant protocols. Certainly, the fact of placing an implant in an infected site may suggest an increased risk of infection, but scientific evidence is giving various proofs, in recent years, of how this risk is also comparable to that of implants type 2, 3 or 4. In fact, there is evidence of how the mechanical and chemical debriding procedures of the post extraction site allow to reduce the presence of bacteria.

The impossibility of verifying the complete removal of the bacterial biofilm from the post-extraction site together with the proven effectiveness of the laser on hard and soft tissues has prompted some authors to propose the use of the laser for the decontamination of the alveoli before implant placement. However, this method has not yet been studied with a controlled clinical trial.

The objective of this controlled study, conducted within at least one year of follow-up after treatment, was to compare the use of immediate post-extraction implants in infected sites decontaminated with Er,Cr:YSGG laser (test) versus conventional implants in edentulous sites (control) in a sample of treated patients.

The specific objectives of the present thesis were:

I. Comparing the difference in marginal bone level (MBL) between the follow-up and baseline (implant placement).

II. Comparing the outcome variables including implant failure and complications (such as mucositis and peri-implantitis).

Material and methods

This study received the approval of the ethics committee of the University of Valencia (n. 1606937298573) and it was performed in strict compliance with the STROBE statements (von Elm et al. 2008). The study was based on a series of patients treated between 2014 and 2019 and with a minimum follow-up of 1 year up to over 4 years (the calculation of the sample size was not necessary as, being a retrospective study, all patients were included in the time period indicated). The study was carried out at the Oral surgery department of the University of Valencia (Spain) in collaboration with the Istituto Stomatologico Italiano of Milan (Italy).

This first phase of the study included the selection of the x-rays (intraoral periapical x-ray taken with the positioning ring and the parallel technique) and the medical records of the included patients. They were patients who received immediate dental implant therapy placed in infected sites decontaminated with lasers or patients who received dental implant with traditional technique. Patients must had a minimum of 1-year follow-up. Additional exclusion criteria were: patients with important systemic diseases, history of radiation therapy, current treatment with steroids, neurological or psychiatric handicap, immuno-compromised status, bruxism, smoking habit (more than 15 cigarettes per day), drug or alcohol abuse and inadequate compliance.

The second phase of this study included the measurement of digital radiographs by a blind operator (R.A.) with a specific software (Image J, National Insitute of Health, Bethesda, Rockville, MA, USA). The following parameters had been used for radiographs: 65-90 kV, 7.5-10 mA and 0.22-0,25 s. Before measurement, each radiograph was calibrated by using the implant diameter and length as reference measures to correct any distortion. The radiographs were measured on a medical screen with a resolution of 1920 x 1080 and with magnification (7x). Marginal Bone Level (MBL) was

measured for baseline and follow-up according to Linkevicius et al., calculating the distance between the implant neck and the first bone-to-implant contact, and taking into consideration both mesial and distal aspect of each implant. For the radiographic analysis, an intra-rater agreement was carried out. An a-priori independent sample of 20 measured implant surfaces were measured twice, 2-weeks apart. The two-way intra-class correlation coefficient for radiographic intra-rater agreement analysis was 0.97 (95%CI from 0.95 to 0.99). The mean and standard deviations for the quantitative variables and the frequency and percentages for the qualitative variables were used as descriptive statistics. The unit of analysis was the implant, taking into account the fact that often multiple implants were used for each patient. A mixed statistical model was used for the outcome variable difference in MBL using the patient as a random effect. The covariate was the MBL at baseline and the group (test or control implant) was the explanatory variable (fixed effect). In order to compare the differences at baseline between the two groups (test implants versus control implants) mixed effects models were used for the quantitative variables age, implant length, implant diameter, MBL at baseline. A mixed effects model was also used to compare the duration of follow-up between the two groups. The patient was the random effect (random effect) and the group (implant test or control) was the explanatory variable (fixed effect). In order to compare the differences at baseline between the two groups (test implants vs. control implants), multilevel models were used for the qualitative variables: gender, smoke, arch (upper or lower), area (frontal - incisors or canines – vs. posterior -premolar or molar-), extraction reasons (fracture vs. other), presence of abscess or fistula, presence of lesion, implants with narrow neck, immediate loading, use of membrane, use of collagen, use of synthetic bone. The models were at two levels (patient and implant) and the group (test implant or control) was the explanatory variable. The significance threshold was set at 0.05. The statistics were performed with the JMP v. 13.0 and with MLwin v. 3.05.

For the surgical phase, all the patients consented to a treatment plan involving the extraction of a compromised tooth, decontamination of the site using the Er,Cr:YSGG laser, and the placement of a

fixture in the same clinical session, in order to replace the missing tooth (test group). The treatment plan was agreed upon after a careful analysis that excluded the presence of contraindications, such as poor oral hygiene or smoking. The patients gave their informed consent for data processing. The surgical phase included an antibiotic therapy (amoxicillin, 1 g twice daily for 6 days) that started the evening before surgery. The local anesthetic used in the interventions was Optocain® (Mepivacaine 1:100.000). The following case report shows the salient phases of the surgical protocol for post-extraction implants in infected sites decontaminated with the Er,Cr:YSGG laser. The compromised teeth were extracted as atraumatically as possible to safeguard the surrounding tissues, assisted by the Er,Cr:YSGG 2780 nm laser. As can be seen from the initial radiograph, elements 3.1 and 4.1 were extracted due to a fracture. The full-thickness flap was raised by the laser with the following settings: configuration for the soft tissue mode, which included tip MC-3, length 9mm, air 20%, and water 80%. For bone tissue, the setting mode included tip MZ-8, length 6mm, air 40%, and water 60%. Once extraction was completed, the decontamination phase of the infected site began. The site was debrided and decontaminated after extraction using the same laser device but with another setting: 2.0W, 20% air, and 80% water, while mounting a MZ-6 tip, 9mm in length. Debridement time depended on the amount of pathological tissue and bone volume, whereas decontamination lasted from 60 to 90 seconds per socket, ensuring no physical contact between the tip and the tissues. The Waterlase iPlus® (Biolase) device was used for all laser procedures. The subsequent phases of the intervention involved the placement of the implants (Straumann®). The fixtures were placed with a minimum 35N torque and 1mm below the most apical bone peak. Often, it was also necessary to place biomaterials for the residual defect caused by the infection, as in this example case: an absorbable membrane (Collprotect®) and Bio-Oss® were used to improve tissue healin. In some cases also synthetic collagen (Septodont®) was used. Sutures (PTFE 3/0 Gore®) were placed with particular care to obtain good flap repositioning. Subsequently, chlorhexidine gluconate gel 0.2% twice daily for 15-20 days was prescribed, and post-operative instructions were given to the patient. Periodic

clinical and radiographic checks were scheduled, and the implants were loaded immediately or after 3 months. In this case the implants were not loaded immediately but the provisional phase was managed with a Maryland bridge. Patients in the control group had followed a similar implant protocol, but tooth extraction had taken place at least 3 months earlier and it was not performed a laser decontamination of the site. The possibility of immediate loading was decided on the basis of some clinical parameters such as the primary stability of the implant in agreement with the patient.

Results

Overall, 98 patients with an average age of 58.0 ± 14.6 years (21 to 88 years), 52 females (53%) and 46 males (47%) were treated; there were a total of 22 smokers in the sample (22%); the retrospective analysis made it possible to analyze a total of 149 implants, 90 (60%) were type test and 59 (40%) control. Only test implants were placed in 53 patients (1 implant in 35 patients, 2 implants in 10 patients, 3 implants in 4 patients, 4 implants in 3 patients and 5 implants in 1 patient). Only control implants were placed in 39 patients (1 implant in 29 patients, 2 implants in 7 patients, 3 implants in 3 patients). Both test and control implants were placed in 6 patients (1 test implant and 1 control implant in 5 patients, 1 test implant and 2 control implants in 1 patient).

The variables relating to the site include different characteristics relating to the implant: upper or lower arch, zone (anterior o posterior), reason for the extraction (fracture, no fracture, abscess or fistula), presence and dimension of periodontal lesion, use of implant with narrow neck, implant length, mplant diameter, use of immediate loading, use of membrane, collagen or synthetic bone, misurement of MBL baseline. In the test group there were more often lesions, the implant length was greater than about 1 mm, the membrane and synthetic bone were more frequently used. In particular, the reasons for extraction in the test group were: caries for 32 teeth (36%), endodontic lesions for 10 teeth (11%), fracture for 43 teeth (48%) and periodontal problems for 5 teeth (6%); and in the control

group: caries for 20 teeth (34%), endodontic lesion in only 1 case (2%), fracture for 31 teeth (52%) and periodontal problems for 7 teeth (12%).

All the implants placed were Straumann, but with different charactertict to be adapted to all clinical situtations. In the test group, the following type of fixtures were used: 33 implants TE RN Loxim SLA Roxolid (37%), 37 implants S RN Loxim SLA Roxolid (41%), 4 implants SP RN Loxim SLA TiZr (4%), 3 implants SP NNC SLAactive TiZr (3%), 4 implants S RN SLAactive Roxolid (4%), 9 implants SP NNC Loxim SLA Roxolid (10%). In the control group, instead, the fixtures were: 6 implants TE RN Loxim SLA Roxolid (10%), 39 impnats S RN Loxim SLA Roxolid (66%), 4 implants SP RN Loxim SLA TiZr (7%), 0 implants SP NNC SLAactive TiZr (0%), 0 implants S RN SLAactive Roxolid (0%), 10 implants SP NNC Loxim SLA Roxolid (17%).

The follow-up was 1.7 ± 0.6 years in the test group and 1.5 ± 0.5 years in the control group, with a non-statistically significant difference (P = 0.082; Mixed model). There was only one failure in the test group (1%) and no failure in the control group. There was only one complication (mucositis) in the control group (2%) and no complications other than failure in the test group. The difference in MBL between the two groups is in favor of the test group which even gains 0.1 mm compared to the baseline while the control group loses 0.1 mm in MBL. However, the difference between the two groups is only 0.2 mm, which is not statistically significant (albeit slightly, P = 0.058).

Discussion

Study outcomes

The main objective was to compare post-extraction implants in infected sites with the traditional technique, where fixtures were placed at least three months after extraction and without signs of residual infections in the alveoli; the results indicate that there is no difference in MBL between two analyzed groups. As a matter of fact the MBL at baseline was 2.4 in both groups (P = 0.912). Since it is not always easy to identify the presence of an active infection when it is necessary to remove a

compromised tooth, type 4 implants were chosen for the control group, therefore positioned in edentulous areas with good healing of the post extraction socket. So in this situation we can be sure that the surgery was performed in an edentulous area free of bacteria..

Summary of main findings

From the results, the two groups appear sufficiently homogeneous in terms of age and gender of the patient and areas treated. The variability and, at the same time, the similarity between the two groups make the comparison of this retrospective study more reliable. Surgical options, such as implant length or use of biomaterials, varied according to the clinical situation. Specifically, in the test group the implants were longer: the implant length was greater than about 1 mm in the test group, and the diameter was almost the same. In addition, except for collagen, which had a similar utilization rate in the two groups, membrane and autologous bone were used more often in the test group. This is because in the test group the presence of lesions was greater and therefore bone defects were also treated more often; the scientific literature also shows that the management of the post-extraction socket often requires the use of biomaterials for peri-implant tissue regeneration. A recent systematic review shows as the bone grafting of the buccal gap simultaneously with immediate implant placement results in preserving hard and soft tissue dimensions; besides, the application of guided bone regeneration techniques aids in soft tissue preservation and prevents resorption of the buccal plate of the immediately placed implant, despite the type of membrane used.

An X-ray image before placing the implant in the post-extraction site after 12 or 16 weeks of healing allows us to check for the presence of osteolytic lesions. However, recent studies show that even after a suitable period of healing time, bacteria may remain in the bone threatening the implant survival. The introduction of the laser in implantology therefore not only makes the immediate technique of positioning the fixture safer: laser decontamination could also be useful in the extraction of teeth with lesions to make future implant rehabilitations more predictable even if performed in a deferred manner.

This study analyzed 149 implants in total, with mesial and distal MBL measurements at baseline and follow-up, and it is therefore to date the only controlled study in the literature on implants placement in infected sites decontaminated with the Er,Cr:YSGG 2780 nm laser, according to the authors' knowledge. Furthermore, the present study includes many cases carried out in the posterior sectors, unlike the many immediate implantology studies (type 1) often carried out exclusively in aesthetic areas, where there is less stress than the masticatory load. In a recent a systematic review and meta-analysis, Lee et al. showed the same encouraging conclusion analyzing five prospective studies, that didn't involve the use of laser but more conventional debridement's technique; the same authors reported the absence of RCTs on the topic in the literature. In a study by Kakar et al., that was recently published, authors followed a clinical protocol similar to the present study including a debridement with Er,Cr:YSGG 2780 nm laser, to treat a case series without control group. However, despite the lack of measurements of the MBL, the interesting data is the survival of the implants which exceeds 95% and is therefore in line with the survival rate that is expected from conventional implantology methods.

Disscussion with previous literature

Considering the results of the 2017 World Workshop on the classification of periodontal and peri-implant diseases and conditions, to evaluate the success of implant therapy it is important to calculate the MBL, that up to 2 mm can be considered as physiologic bone remodelling. The other factors considered are: visual inspection demonstrating the absence of periimplant signs of inflammation: pink as opposed to red, no swelling as opposed to swollen tissues, firm as opposed to soft tissue consistency; lack of profuse (line or drop) bleeding on probing; probing pocket depths could differ depending on the height of the soft tissue at the implant location. An increase in probing depth over time, however, conflicts with periimplant health. The data obtained on the MBL in this research is not only in line and lower compared to the control group, but it is also comparable to that of other studies. Among these, Berberi et al. described the MBL in immediate and delayed loading techniques

of post-extraction implant; the immediate loading seems to guarantee promising clinical results like the ones showed by several cases in the present study. In fact, as in the present study, also in the work of Barbieri and collaborators, significantly lower MBL associated with immediately loaded implants inserted into fresh extraction sockets was observed when compared to the delayed loading technique. Thus, the suggested hypothesis that greater MBL would be observed in immediately loaded implants was rejected. The rapid and reproducible reformation of peri-implant mucosa within the gingival embrasures can be attributed to minimal MBL, immediate delivery of the interim prostheses, and absence of abutment manipulation during the healing period. Regarding loading and prosthetic phases, this study involved a similar percentage between the test group and the control group of immediate loading cases. This makes the analysis more complete and adds a number of variables which, however, did not influence the clinical and statistical results. Another clinical motivation, about the difference between MBL in the two groups, may derive from the fact that regenerative techniques are often combined in post-extraction implant situations due to bone defects.

Efforts, limitations and recommendations for future research

Previous studies, comparing panoramic and periapical radiographs indicated periapical radiographs as the “gold standard” for measuring MBL around dental implants. CBCT would also be useful but due to the dose of rays and lack of justification it would not be possible to find a considerable number of patients for the study. The 3D radiographic examination was used only in some cases, as reported in the results, and was also performed for other clinical needs. The need to have comparable radiographs has led to a scrupulous selection of patients in order to increase the reliability of the data. This could be a limitation of the present study. In this context, another limitation of the present study was the relatively small number of implant losses; specifically, due to the small number of implant losses, a random-effects logistic regression analysis was not meaningful and hence, the herein recorded potential predictors could neither be related to early nor to late implant loss. Furthermore, it is a retrospective study, which therefore implies the presence of some bias, although with a protocol

already published in previous studies by the same authors. Finally, another limitation of the study is that, in both groups, antibiotic prophylaxis was administered to the treated patients. This is because even the latest scientific evidence suggests the use of the antibiotic to prevent premature loss of implants. According to the authors of a recent review of the scientific literature, basing on the available RCTs, the use of antibiotic prophylaxis is protective against early implant failures, but there is still insufficient evidence to confidently recommend a specific dosage. The use of post-operative courses does not seem however to be justified by the available literature.

Conclusions

The following conclusions can be drawn from the present thesis:

I. The result that there is no difference in MBL, which is even almost better in the test group, seems promising for the clinical application of the described protocol for placement of type 1 implants in infected sites.

II. The complication or failure rate is comparable between the two groups and therefore there is no increased risk in the test group.

ANNEXES

14. ANNEXES

- Ethics committee;

- Clinical protocol.

El comité Ético de Investigación en Humanos de la Comisión de Ética en Investigación Experimental de la Universitat de València,

CERTIFICA:

Que el Comité d'Ètica d'Investigació en Humans, en la reunión celebrada el día 03 de Diciembre de 2020, una vez estudiado el proyecto de tesis doctoral: *"Implantes dentales inmediatos posicionados en alvéolos post-extractivos con infección descontaminados con láser: estudio de cohortes retrospectivo."*,

Cuyo/a responsable es D/Dña.

DAVID PEÑARROCHA OLTRA, dirigida por D/Dña. DAVID

PEÑARROCHA OLTRA

ha acordado informar favorablemente el mismo.

Y para que conste, se firma el presente certificado

Av. Blasco Ibáñez, 13 tel: 963864109 vicerec.investigacio@uv.es
València 46010 fax: 963983221 www.uv.es/serinves

Firmado digitalmente por
PEDRO JESUS PEREZ ZAFRILLA
Cargo: Presidente del Comité de Ética de la Investigación en Humanos
Fecha: 04/12/2020 12:58:24 CET

The Ethics Committee of Research in Humans of the Ethics Commission in Experimental Research of University of Valencia,

CERTIFY:

Hereby certify that the Ethics Committee of Research in Humans, in the session which took place on diciembre 03, 2020, analysed the project of doctoral thesis entitled *"Immediate dental implants placement in post-extraction-infected sites decontaminated with laser: a retrospective cohort study."*, whose researcher in charge is DAVID PEÑARROCHA OLTRA, and agreed with this project.

And in witness whereof, I hereby sign this certificate

Av. Blasco Ibáñez, 13 tel: 963864109 vicerec.investigacio@uv.es
València 46010 fax: 963983221 www.uv.es/serinves

Comité d'Ètica d'Investigació en Humans de la Comissió d'Ètica en Investigació Experimental de la Universitat de València,

CERTIFICA:

Que Comité d'Ètica d'Investigació en Humans, en la reunió que tingué lloc el dia 03 de desembre de 2020, una vegada estudiat el projecte de tesi doctoral titulat:*"Implants dentals immediats posicionats en alvèols post-extractius amb infecció descontaminats amb làser: estudi de cohorts retrospectiu."*,

que té com a responsable

DAVID PEÑARROCHA OLTRA, i que va dirigir DAVID PEÑARROCHA OLTRA,

ha acordat emetre'n un informe favorablement.

I perquè així conste, signa aquest certificat.

Av. Blasco Ibáñez, 13 tel: 963864109 vicerec.investigacio@uv.es
València 46010 fax: 963983221 www.uv.es/serinves

CIRU BUCA

Immediate dental implants placement in post-extraction-infected sites decontaminated with laser: a retrospective cohort study

Centre: _____ Operator: _____

1. First name and last name: _____
2. Medical history n. ____
3. Age: ____
4. Gender: M□ F□
5. Smoker: no□ yes□ ____ (n. of cigarette)
6. Dates of x-ray: pre-op._____ post-op._____ follow-up_____ (n. of years__)
7. Tooth or teeth treated: ____
8. Extracted for: caries□ endodontic lesion□ fracture□ periodontal diseases□
9. Group: Test□ (type I implant in infected site) Control□ (type IV implant in non-infected site)
10. Type of apical lesion: not visible□ 0<x≤5mm□ x>5mm□ (larger ø)
11. Decontamination: no□ laser (type_____)□ other (type_____)□
12. Type of implant: 1□ 2□ 3□ 4□
13. Length of the implant: ____
14. Type of loading: immediate□ early□ conventional□
15. Biomaterials: no□ membrane□ collagen□ bone□
16. Gingival graft: no□ yes□
17. Complication: no□ mucositis□ peri-implantitis□
18. Failure: no□ yes□ after ___years
19. Baseline MBL: Mesial _____ Distal _____
20. Follow-up MBL: Mesial _____ Distal _____