An update in periapical surgery

Eva Martí-Bowen [1], Miguel Peñarrocha [2]

(1) Dentist in private practice
(2) Assistant Professor of Stomatology. Director of the Master of Oral Surgery and Implantology. Valencia University Dental School. Valencia, Spain

Correspondence:
Dr. Miguel Peñarrocha Diago
Clínica Odontológica
C/ Gascó Oliag 1.
Valencia 46021
E-mail: Miguel.Penarrocha@uv.es

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ABSTRACT
Periapical surgery has largely improved at all levels due to new technologies provided by researchers throughout the last years. The aim of this article is to carry out a bibliographic revision of the last seven years. For this reason, we will analyse the studies published in Medline and the most important spanish dental magazines. The subjects to investigate are mainly based on the incorporation of ultrasonic root-end, which allow the performance of small and adjusted retrograde cavities; as well as the new filling materials. We also include magnifying glasses or surgical microscope to the work material, plus surgical laser and the application of guided tissue regeneration.

Key words: *periapical surgery, apicoectomy.*

RESUMEN
En los últimos años, la cirugía periapical ha mejorado a todos los niveles debido a las nuevas aportaciones técnicas proporcionadas por los investigadores. El objetivo del presente artículo es realizar una revisión bibliográfica de los trabajos de los últimos siete años, analizando los estudios publicados en el Medline y las principales revistas odontológicas españolas. Los temas de investigación se centran principalmente en la incorporación de las puntas de ultrasonidos que permiten realizar pequeñas y ajustadas cavidades retrógradas; así como los nuevos materiales de relleno para las mismas, capaces de conseguir un mejor sellado apical. También se incorporan las lentes de aumento o el microscopio quirúrgico al material de trabajo, así como el láser quirúrgico y la aplicación de la regeneración tisular guiada.

Palabras clave: *Cirugía periapical, apicectomía.*

INTRODUCTION

In 1996, Sumi et al. (1) presented periapical surgery as one of the least understood and most inadequately performed of all oral surgical techniques. Nevertheless, in 1998, Cohn (2) proposed periapical surgery as a predictable option when root-end canal treatment is either not possible or fails. The present article reviews the literature on advances in periapical surgery, based on a Medline search and on the Spanish dental journals, corresponding to the period 1996-2002.

Sumi et al. (1) reported percentage success rates in the studies over the past 20 years of close to 50% - these figures being far lower than those described in recent studies using ultrasound. In effect, the new ultrasonic tips allow for smaller ostectomies with improved cleanliness of the surgical field and the preparation of a smaller apical cavity without the need for beveling. The risk of root perforation is also reduced. Current success rates with this technique are in the range of 85-94% (1-5). Table 1 shows the success rates reported by studies involving follow-up durations of one year or more, published in 1996-2002 (1,4-17). However, homogenization of the criteria used to rate success is required, since controversy exists on this point. In 1999, von Axel and Kurt (11) revised the success criteria, modifying those established in 1991 by Zetterqvist et al. (18), and in 1995 by Jesslen et al. (19). According to Zuolo et al. (12), it is important to conduct prospective studies to objectively evaluate the prognosis of periapical surgery. On the other hand, for these clinical evidence-based studies it is essential to adopt a surgical protocol. In this context, the surgical guidelines proposed by the Spanish Society of Oral Surgery were defined on occasion of the second National Congress of Oral Surgery held in Seville in 2001 (20).

IMAGING DIAGNOSIS IN PERIAPICAL SURGERY

In relation to periradicular lesions, Holtzmann et al. (21) obtained high-resolution digital images, improving upon conventional X-rays, with only half the amount of radiation exposure. Farman et al. (22) compared standard periapical X-rays with digitized images; 14 investigators measured the mesiodistal and vertical size of 28 periapical lesions with both radiological systems – digital imaging being shown to be more precise.

Sullivan et al. (23) in turn compared digital radiology using two types of contrast for image processing – adjustable and non-adjustable – versus the conventional radiographic method, in 16 lesions corresponding to 6 human mandibles. Three examiners performed the three preoperative radiological techniques. Following ostectomy, the larger the lesion the greater the precision of the radiological technique used. On the other hand, for the smaller lesions, digital radiology with adjustable contrasting was found to be somewhat more precise than the conventional technique.

Velvart et al. (24) compared conventional radiography and computed tomography (CT) in application to periapical lesions in 50 patients programmed for periapical surgery. The implicated teeth comprised 44 mandibular molars and 6 premolars. Eighty supposed periapical lesions were evaluated by means of a periapical X-ray and a CT image. A total of 78 lesions were diagnosed at surgery; all had been identified by CT, while in contrast periapical radiology identified only 61 lesions. CT afforded a clear image of the mandibular canal in all cases, versus in only 31 cases on employing the conventional radiological technique.

In a micro-CT study (25), quantifications were made of the architectural changes in the periapical bone of very small lesions. The results obtained approached those afforded by histology. On the other hand, Furusawa and Asai (26) used scanning electron microscopy (SEM) to measure the apical foramina of 25 apicoectomized teeth diagnosed with suppurative periapical periodontitis. In all of them dimensions of over 350 µm were recorded as a result the chronic microbial infection – the reason being endodontic overinstrumentation (exceeding file size 35) or fistulization. The authors indicated the possibility of performing periapical surgery in these cases.

SURGICAL TECHNIQUE

The surgical technique is a fundamental consideration, since it largely conditions the prognosis of periapical surgery (1,15). Rahbadan et al. (15), in a study conducted in a teaching dental hospital, found the total healing rate after four years of follow-up of 83 teeth treated in en endodontics unit to be 37.4%; in comparison, the total healing rate of the 93 teeth treated in an oral surgery unit reached only 19.4%. These are by far the lowest indices referred in the literature corresponding to these years. According to the authors, surgical practice in separate oral surgery and endodontics units can impair the performance of both; mutual interaction between both groups is therefore seen as positive and improves management performance.

Danin et al. (9) in 10 cases performed periapical surgery and retrograde filling with silver amalgam, in teeth not subjected to endodontic treatment. The X-ray control study after one year showed complete healing in 50% of cases, and uncertain healing in the remaining 50%. However, the presence of germs was confirmed within the canals in 9 of the 10 apexes studied – with the potential risk of relapse this implies. Sauveur et al. (27) in turn described a curious technique involving retrograde filling with gutta-percha, preparing the root-end cavity perpendicular to the axis of the tooth and parallel to the apex section.

Regarding periapical surgery in molars, von Arx et al. (14) reported an 88% success rate in their prospective study. Peñarrocha et al. (16) in turn recorded a 90.4% clinical healing rate, while radiologically the figure was 54.8% (Table 1). In the upper premolars and molars, Rud and Rud (28) described a 50% incidence of maxillary sinus perforations in a series of 200 maxillary first molar apical resections. Freedman and Horowitz (29) studied the sinus complications related with this technique in 472 apicoectomies among 440 patients. Sinus membrane perforation was recorded in 10.4% of cases, though none gave rise to symptoms of acute or chronic sinusitis. Periapical surgery is advised as habitual practice for these teeth before resorting to extraction, since the complications caused by a potential maxillary sinus perforation are minimal.

In lower molars with a thick mandibular cortical component, Peñarrocha et al. (30) advocate a window ostectomy using circular trephine drills, which facilitate access to the lesion and moreover allow repositioning of the bone lamina after completing the apicoectomy.

VISIBILITY OF THE SURGICAL FIELD

Good access to and visibility of the surgical field is one of the principal requirements of periapical surgery. The use of micromirrors, fiber optics, surgical microscopes or magnifying lenses have largely resolved this problem (31). Bahcall et al. (32) employed an endoscope to improve visualization of the operating field in periapical surgery, facilitating illumination and location of the root apexes – and thereby improving the quality of the surgical procedure.

The use of a dental microscope improves access to the surgical field in periapical surgery (33). The instrument comprises a binocular fiber optic system with five types of magnifications. The device can be suspended from the ceiling, and its inclination can be adjusted. Thanks to its lens system, the microscope can identify the dental and periodontal anatomy, as well as the limits of the periapical lesion, and allows performance of a minimal ostectomy. Its main inconveniences are its great cost, the need for training in its use, and the fact that it prolongs surgical time.

HISTOPATHOLOGY

Holtzmann et al. (21) showed histopathological study to be the most reliable means for diagnosing periapical lesions. Dahlkemper et al. (34), in a retrospective study of 79 central giant cell granulomas, found the latter to characteristically manifest as a periapical lesion, and reported that many such granulomas may go unnoticed. They pointed to the importance of subjecting periapical lesions to histological study on a systematic basis. Kuc et al. (35) showed that in 5% of cases of periapical pathology, the biopsy study served to modify the initial preoperative diagnosis. As exemplified by the case described by Hollows et al. (36), a radiotransparency simulating a periapical lesion may actually prove to be malignant. Philipsen et al. (37) published the case of a 15-year-old patient with various radiotransparent periapical lesions that were shown by the microscopic study to correspond to an extrafollicular variant of an adenomatoid odontogenic tumor.

PROCEDURE FOR ROOT-END CAVITY PREPARATION USING ULTRASOUND

The introduction of ultrasound in root-end cavity preparation constituted an important step forward in periapical surgery (31). In the year 2000, Von Arx and Walker (38) reviewed the literature, analyzing the microsurgical instruments used for root-end cavity preparation, the advantages afforded by ultrasound microtips for performing the technique, the controversy over whether cracks or microfractures are produced, and their implications for the long-term success of surgical management.

With the introduction of ultrasound, the success rates in periapical surgery have increased from 50-75% in the 1980s (39-41) to a more encouraging 82% (11) or 92.4% at present (1). In this sense, Peñarrocha et al. (13) compared the success of periapical surgery based on the use of rotary instruments versus ultrasound; the percentage of clinically and radiologically healed cases was found to be greater with ultrasound (82%) than with the conventional rotary technology (51%).

Difficulties may be encountered in accessing the root apex, due to the existence of very long roots, a palatal or lingual inclination of the apex, or the proximity of neighboring anatomical structures. A number of solutions can be proposed in such cases. Thus, the bony window can be enlarged, further apical sectioning can be decided, or the mesial or distal zone of the root can be beveled to allow lateral entry of the ultrasound tips. Although the latter offer the advantage of preparing cavities of minimum diameter, in those cases where fine apexes are found at least 2 mm of root structure must be left surrounding the final sealing cavity. Further root sectioning may be required to secure this perimeter, thereby avoiding the production of cracks at the apical tip due to the ultrasound power rating and vibrations (42,43). Min et al. (43), in an electron microscopic study of extracted teeth, reported an increased appearance of cracks and fissures on using ultrasound tips. These root surface irregularities may in turn provide a location for bacterial growth and the concentration of toxic and peri-root irritating metabolites. The authors postulated that this incidence of surface irregularities increases when the ultrasound power rating is maximum, as a result of the energy and heat emitted by the vibrating ultrasound tip on the canal walls. According to Gay et al. (31), however, these cracks observed in vitro are not directly caused by the ultrasound tips, since extracted teeth present cemento-dentinal alterations such as cracks as a consequence of dehydration.

Abrasive sonic and diamond-surfaced retrotips have been commercialized, offering increased cutting capacity, with good results (11). Nevertheless, Zuolo et al. (44) observed more root canal irregularities with these diamond-surfaced tips. This aspect remains open to controversy and should be addressed by long-term studies, since other authors have reported no differences between diamond-surfaced tips and conventional smooth tips (45). Calzonetti et al. (46), Brent et al. (47), Gray et al. (48), and Morgan and Marshall (49) observed no increased production of cracks when using sonic and diamond-surfaced retrotips.

According to most authors (4,11,31,44,47,49,50), the use of ultrasound improves the prognosis of periapical surgery, increasing percentage success and final healing. Peñarrocha et al. (5) reported a radiological and clinical success rate of 87.7% in 122 cases of periapical surgery (155 teeth) performed with ultrasound, with a failure rate of 5.5% (7 cases)(Table 1).

Table 1. Periapical surgery success rates in the period 1996 - 2002.
Authors, type of study and no. teeth / no. molars / percentage success

Authors	Type of study Follow-up	No. teeth (max/mandib)	No. molars (max/mandib)	Percentage success
Sumi et al. (1) (1996)	retrospective 6 months to 3 years	157 (131/26)	23 (17/6)	92.4%
Molven et al. (6) (1996)	retrospective 8 – 12 years	24 (24/-)	_ _	96.0%
August (7) (1996)	retrospective 10 years	16 (16/-)	8 (8/-)	62.5%
Jansson et al. (8) (1997)	retrospective 11 – 16 months	56 (49/7)	_ _	85.0%
Danin et al. (9) (1999) 1 year	retrospective (-/-)	10 _	_	50.0%
Testori et al.(4) (1999)	retrospective 1 – 6 years	181 (130/51)	_ _	77.5%
Rubinstein and Kim (10) (1999)	retrospective 14 months	94 (-/-)	31 (-/-)	96.8%
von Arx and Kurt (11)(1999)	prospective 1 year	50 (43/7)	4 (2/2)	82.0%
Zuolo et al. (12) (2000)	prospective 1 – 4 years	102 (73/29)	39 (20/19)	91.2%
Peñarrocha et al. (13)(2000)	retrospective 1 year	61 (-/-)		85.0%
von Arx et al. (14)(2001)	prospective 1 year	25 (9/6)	25 (9/6)	88.0%
Rahbaran et al. (15)(2001)	retrospective 4 years	83 (endodontic unit) 93 (surgery unit) 176 (total)	 14 (total)	37.4% 19.4%
Peñarrocha et al. (5)(2001)	retrospective 3.5 years on average	155 (98/57)		87.7%
Peñarrocha et al. (16)(2001)	retrospective 1 year	31 (-/31)	31 (-/31)	90.4% (Clinical) 54.8% (Radiological)
Rubinstein and Kim (17)(2002)	retrospective 5 to 7 years	59 (roots)		91.5%

LASER IN PERIAPICAL SURGERY

Lasers are currently used with very good results in periapical surgery for apex resection or for improving apical sealing following apicoectomy and retrograde filling. The main advantages of the CO2 laser in periapical surgery comprise improved hemostasia and visualization of the surgical field, possible sterilization of the root end, reduction of dentinal surface permeability, a reduced risk of contamination of the surgical area, and a reduction in postoperative pain (51). However, Bader and Lejeune (3) consider that the CO2 laser does not afford advantages over ultrasound in root-end preparations, and even point to the superior utility of ultrasound with respect to laser. The Erbium-YAG laser has shown great potential in application to periapical surgery. The thermal damage induced by this laser in soft tissues, bone and other structures is comparatively less than with other laser systems, as a result of which postoperative discomfort is lessened (52). Different authors have evaluated ruby, CO2, Nd:YAG, Er:YAG, excimer and argon laser (3,53) and their effects upon soft and hard tissues, as well as on dental materials and instruments. Gouw-Soares et al. (54), combined three types of laser for periapical surgery in a patient; the Er:YAG laser was used for ostectomy, and in application to apicoectomy they were able to reduce vibration upon sectioning the hard tissues. The Nd:YAG laser was in turn used to seal the dentin tubules and reduce the number of bacteria present in the bone cavity, while the Ga-Al-As laser reduced postoperative patient discomfort. After three years of follow-up, clinical and radiological healing was confirmed. According to the advocates of laser application to periapical surgery, the main advantages with respect to rotary instrumentation comprise a reduction in tissue trauma and the risk of contamination (3) – though further studies are required to assess the cost/benefit ratio involved.

RETROGRADE FILLER MATERIALS

Different filler materials have been used, such as glass ionomers, IRM, gallium alloys, gold or composite resins, with different results (39). Johnson (55) reviewed the different retrograde filler materials, stressing the indications and contraindications of each of them. At present, research is particularly centered on zinc oxide-eugenol cements: EBA and super-EBA, and on MTA (Mineral Trioxide Aggregate).

Peters and Peters (56) analyzed marginal adaptation and crack formation with super-EBA and MTA after subjecting them to occlusal loads equivalent to those generated by masticatory movements for 5 years, based on the use of a computer-controlled masticator and scanning electron microscopy (SEM). both materials were found to offer excellent marginal adaptation, with somewhat superior performance when using MTA. Sutimuntanakul et al. (57) in turn experimentally investigated the sealer properties of MTA in relation to other materials used for retrograde filling such as super-EBA, Ketacfill and thermoplasticized gutta-percha. They reported less leakage with MTA versus amalgam. Torabinejad et al. (58) and Nakata et al. (59) suggested that MTA induces healthy apical tissue formation more often than other materials, as a result of the lesser inflammation produced. In this sense, Regan et al. (60) compared the properties of MTA and Diaket® (polyvinyl resin initially used to seal root canals) for promoting periradicular bone regeneration – no significant differences being observed between the two materials. However, Zhu et al. (61) described increased human osteoblast adhesion to MTA and composite versus IRM and amalgam. Witherspoon and Gutmann (62) in turn analyzed the healing response of periapical tissues in relation to the use of Diaket® and gutta-percha, with superior results for the former material. Maeda et al. (63) investigated periapical inflammatory response in relation to a resin (4-META-TBB superbond) and a photopolymerizing composite, versus amalgam. Improved results were obtained with the resin and composite, due to their increased biocompatibility. Koh (64) presented a clinical case in which MTA was used as retrograde filler material, with very good results. MTA has also been shown (65) to adapt well to tissues in retrograde filling of an open-apex tooth.

A number of studies (66-74) have investigated the sealing capacity of materials used for retrograde filling. It is difficult to compare these studies, however, due to differences in the treatment parameters involved, the filler materials and techniques employed. Nevertheless, Zhu et al. (75) evaluated the cytotoxicity of amalgam, IRM and super-EBA upon the cells of the human periodontal ligament and osteoblastic cells – increased cytotoxicity being recorded for amalgam.

GUIDED TISSUE REGENERATION

Guides tissue regeneration (GTR) is increasingly applied in the field of periapical surgery, where it accelerates bone formation in the remnant defects after surgery, by filling the bone cavity with different materials such as porous hydroxyapatite, and dehydrated and demineralized cortical bone. These regeneration techniques can also be successfully used to treat large lesions, or in situations where both cortical components are affected (76).

Pompa (77) reported that the success of periapical surgery can be increased with GTR. According to Gay et al. (31), in situations of external or internal cortical table losses of 5 mm or more, non-reabsorbable or reabsorbable membranes can be positioned, thus allowing the surrounding osteoblastic cells to fill and repair the bone defect. In this context, it is advisable to ensure a minimum base of 3 mm of healthy bone around the defect. Regan et al. (78) reported very good results with exogenous growth factors applied to periapical bone regeneration, in experimental studies in dogs.

PERIAPICAL SURGERY AND IMPLANTS

Periapical surgery has recently been used to treat periapical peri-implantitis. These are inflammatory lesions appearing in the apical zone of implants, and which are cleaned and subjected to curettage (79); apical resection of the implant may even be performed in order to avoid bacterial proliferation and relapse of the eliminated lesion (80,81).

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