Ultrasonic tips in periradicular surgery

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Abstract
Technological advances have increased the rate of success of dental procedures. In periradicular surgery, the use of ultrasonic tips ensures high-quality root-end cavity preparations, enables the performance of a 90-degree apicoectomy, and removes larger amounts of contaminated material. The authors reviewed in vitro and in vivo studies in the literature and evaluated root-end cavities prepared with burs or ultrasonic tips using scanning electron microscopy.

Keywords: Endodontics; Oral Surgical Procedures; Apicoectomy.

INTRODUCTION

Ultrasonic systems for the preparation of apical cavities have been developed to overcome the deficiencies of conventional methods. Ultrasonic tips are not rotary and have an angulation that is different from that of handpieces conventionally used in periradicular surgery. They provide better access to the apical end; apical resections may be performed at 90 degrees to the long axis of the root canal, and a greater amount of mineral structure can be preserved, which reduces the risk of perforations and the number of sectioned dentinal tubules.

LITERATURE REVIEW

Gagliani, Taschieri and Molinari[1] recommended that the depth of apical cavities should be at least 3 mm to ensure a safe and effective apical seal. Navarre and Steiman[2] added that root-end cavities should incorporate the largest possible number of accessory root canals (apical delta). Root-end cavity walls should be parallel and follow the direction of the root canal.[3]

Wuchenich, Meadows and Torabinejad [4] conducted a study with teeth from human cadavers and found that ultrasonic (US) tips produced more parallel walls and deeper cavities. Mean depth was

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2.5 mm, which provided better retention than bur preparations, which reached a mean depth of 1 mm. US tips also followed the direction of the canals more closely, whereas inverted cone burs in a slow-speed handpiece deviated 45 to 60 degrees. They compared scanning electron microscopic (SEM) samples and confirmed that there was less superficial debris and smear layer in the root-end cavities prepared with US tips. A SEM in vitro study conducted by Gorman, Steiman and Gartner [5] showed that root-end cavities prepared with US tips alone or in combination with rotary burs had less debris than those prepared with rotary instrumentation alone. This may be assigned to the combination of sufficient irrigation and vibration to remove debris and smear layer from the dentinal walls. The time recommended by the author for root-end preparation is 1 to 3 minutes.

In an in vitro study, Sutimun-tanakul, Worayoskowit and Mangkornkarn [6] concluded that root-end cavity preparation with US tips improves the distribution of material inside the cavity and provides a more efficient apical seal.

C.I. Peters, O.A. Peters and Barbakow [7] explained that the better performance of US tips might be assigned to the fact that access to root-end cavity preparation is limited, and concluded that root-end preparation with burs results in inadequate sealing and, thus, a poor prognosis. Engel and Steiman [8] compared the use of US units with conventional instrumentation using a micro-handpiece for apical preparation. Several advantages were reported in the comparison with US, particularly when the risk of root perforation was high or when the access to the apex was limited.

Findings of the study conducted by Waplington, Lumley and Blunt [9] suggested that the use of US tips that were smaller than handpiece instruments was a safer and more effective method of resection and root-end preparation and had clear advantages as an alternative technique.

According to Navarre and Steiman [2], the design of US tips provides direct access to the canal and requires less bone removal to expose the root apex. Gilheany, Figdor and Tyas [10] compared the differences of apical resection (bevel angulations) and the different depths of root-end cavities. They found that an increase in cavity depth resulted in a decrease in apical microleakage; however, when the bevel angle was increased, greater dye infiltration was found. This may be explained by the exposure of a greater number of dentinal tubules, which may lead to cavity contamination. The same authors reported on the importance of increasing the depth of the apical cavity when the bevel angle of apex resection had to be greater.

Gagliani, Taschieri and Molinari [1] studied the difference between 90- and 45-degree apical root resections. The prepared cavities with US tips in extracted teeth and compared dye infiltration in the two groups. They found greater dye penetration both in dentin and in the interface between tooth and root-end filling material in the group with the 90-degree angle. They also found less dye infiltration in teeth with the 90-degree apical resection angle. Anatomically, they noted that the greater the resection angle, the greater the number of sectioned and exposed dentinal tubules. However, when apical sealing was well performed all along the cavity depth, no substantial differences were found in infiltration rates for different types of resection.

Vertucci and Beatty [11] suggested that infiltration might be promoted by the increase in the acute angle of dentinal tubules as the apical third of the root is approached. Ichesco and others [12] found that a greater mineralization of dentinal tubules occurs with aging, which reduces apical microleakage in teeth of elderly people. Gondim and others [13] reported that sonic and ultrasonic devices provided a more conservative and better aligned root-end preparation. However, microfractures and dentinal chips might result from the vibratory action of these instruments. They confirmed the similarity of these two types of instruments in their studies.

Calzonetti and others [14] reported that microfractures found after cavity preparation increased chances of apical microleakage because dentinal permeability increased too. According to Navarre and Steiman [2], diamond-coated tips were introduced in the market to minimize dentinal fractures because they remove dental structure faster, and thus decrease contact time during instrumentation.

C.I. Peters, O.A. Peters and Barbakow [7] found that there was no correlation between the incidence of microfractures and a preparation time

greater than 2 minutes with the use of US tips. According to Gondim and others [13], if US tips were used according to manufacturer's instructions, dentinal fractures would not occur. Following the same line of investigation, Calzonetti and others [14] found that the use of US tips in the preparation of root-end cavities was not responsible for microfractures in the dentinal structure. Their analyses were conducted using SEM.

Morgan and Marshall [15] obtained resin impressions of root-end cavities performed in vivo using US tips, and found dentinal fractures in only 25 of the roots evaluated using SEM. Their findings may be explained by the method used for impressions. They concluded that US tips could be used for the preparation of root-end cavities. They also found that, after root-end preparations, marginal dentinal chipping was often found in the interface between canal walls and root surface.

Zuolo and others[3] compared root-end cavities prepared with smooth and diamond-coated US tips. They found that diamond-coated tips seemed to have a better cutting action, but smooth tips produced a cleaner and smoother surface. They suggested the combined use of both. They suggested that preparation should begin with diamond-coated tips to take advantage of their better cutting action, and be followed by preparation of the main cavity and removal gutta percha, and by the use of a smooth tip to produce a cleaner and uniform cavity. They also compared the use of smooth and diamond-coated US tips on the internal and external surfaces of root-end cavities, and found no significant differences on the external surface. However, in the internal surfaces, the smooth tips produced clean, smooth cavities with little debris or smear layer, whereas the use of diamond-coated tips resulted in irregular cavities and chipping.

C.I. Peters, O.A. Peters and Barbakow [7] compared US tips and found that stainless-steel tips removed less dentin than diamond-coated tips. They found that diamond-coated tips prepared root-end cavities in less time and produced an excellent cavity with less risk of microfracture than stainless steel tips because the use of US tips required less pressure. They also concluded that, although none of the tips produced a significant number of microfractures, special care should be taken when using diamond-coated tips to avoid removing too much dentinal structure.

Khabbaz and others [16] reported that preparation with US tips produced fewer intradentin cracks, which were not associated with the apical surface but, rather, with the type of tip used. Moreover, US tips produced cleaner, well-centered and more conservative root-end cavities than rotary instruments.

Navarre and Steiman [2] reported that US tips could be better controlled by the dentist. As the root-end cavity was centered along the long axis of the root canal, US tips posed a lower risk of perforation.

Gondim and others [13] reported that diamond-coated tips sometimes could not be passively introduced in the root canal because of their diameter, and recommended that preparations begin with a stainless-steel tip to facilitate the subsequent introduction of the diamond-coated tip.

Rainwater, Jeansonne and Sarkar [17]conducted a study to evaluate dye infiltration and fractures after root-end cavity preparation with burs in a handpiece, stainless-steel tips, or diamond-coated tips, and found statistically significant differences in microfractures between the three methods of root-end cavity preparation. A difference in dye infiltration was also found between root-end cavity preparations with stainless steel and diamond-coated tips. A study conducted by Ishikawa and others [18] compared the efficiency of root-end cavity preparation with different types of US tips. They found no differences in number of cracks or depth of root-end cavity between the three types of US tips (diamond-coated, zirconium nitride-coated, or stainless steel).

In the study conducted by Gondim and others [13], no significant differences were found in cutting action or cracks between the different types of US tips. Tobón-Arroyave and others [19] reported that cracks might occur regardless of the thickness of dentinal wall, and that they might be associated with the prolonged use of US tips to remove canal filling during root-end preparation.

A previous study by Calzonetti and others [14] showed that the incidence of microfractures depended on the intensity and duration of ultrasound vibration. Therefore, they suggested that

root-end cavities be prepared with low to moderate intensity for 2 minutes to reduce the risk of dentinal microfractures. They added that there seemed to be a greater susceptibility to fracture when US tips were used in thin roots of posterior teeth. They concluded that US tips do not cause fractures in endodontically treated teeth.

De Bruyne and De Moor [20] compared the integrity of resected root apices and root-end cavity preparation of cadaver and extracted teeth with US tips at different intensities. They found that the number of cracks and the degree of chipping caused by US preparation was greater in extracted than in cadaver teeth. They also found that the use of US tips at low intensity should not be recommended because it caused more cracks and equal chipping in cadaver teeth.

Wälivaara and others [21] showed that the success of US root-end preparation also depended on which teeth were treated: the success rate for incisors reached 100%, whereas for premolars and molars, it was only 78% and 69%.

METHODS

Following bioethics principles, two extracted human canines were used to evaluate root-end cavities prepared with burs or US tips using SEM. The apex of one of the teeth (tooth A) was sectioned from the mesial to the distal surface at 3 mm from the apical end at a 90-degree angle with the long axis of the tooth using a round high-speed diamond-coated bur (KG® Sorensen) under constant irrigation with 0.9% sodium chloride. The same procedures were used for the other tooth (tooth B), except that angulation was 45 degrees.

The root-end cavity of tooth A was prepared with an US unit (Jet Sonic Four Plus, Gnatus®) and diamond-coated tips (S12/90D, Gnatus®). The US unit was set at S (scaling) and was operated under continuous irrigation. The tip diameter was slightly greater than that of the apical portion of the root canal. Therefore, the root-end cavity had the same diameter as the tip; depth was 2 mm, which was the size of the US tip, and the preparation followed the anatomic direction of the root canal. [22] The root-end cavity of tooth B was prepared with a #2 round stainless-steel bur in a slow-speed handpiece. This bur was marked at 2 mm beyond its apex to ensure that the cavity would have this same depth.

The specimens were prepared for SEM, and images were obtained from photomicrographs (FIGURE 1; FIGURE 2) of apical surfaces resected with a bur and of the areas of root-end preparation with US tips or burs.

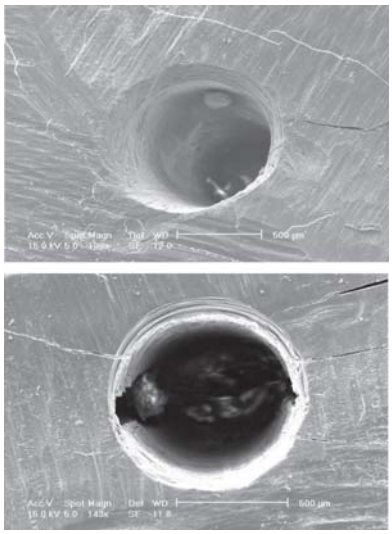

Figure 1 - Apicoectomy performed with bur at 90 degrees, and root-end cavities prepared with US tips

Note: SEM images of surface (original magnification = 109x)

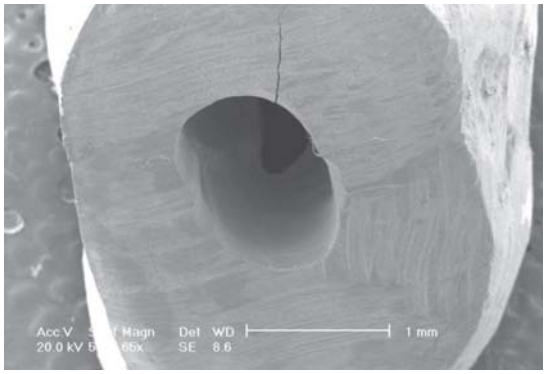

Figure 2 - Apicoectomy performed with bur at 45 degrees, and root-end cavity prepared with round bur

Note: SEM images of surface (original magnification = 65x)

DISCUSSION

Some in vitro studies showed that US tips produced fractures in the dentinal structure. [7, 15] Morgan and Marshall [15] suggested that this was a result of the stress generated during extraction of the teeth used in these studies, associated with dehydration and type of storage. Rainwater, Jeansonne and Sarkar [17] added that microfractures might occur at the time of root resection, but that they might become apparent only at the time of root-end cavity preparation. Gondim and others [13], moreover, reported that the method used, and the variation in microscopic magnification, might affect the number of fractures found in root-end cavity preparations.

Most studies reviewed here reported on in vitro studies, which serve as preliminary evaluations for the use of a new treatment in patients. Most authors agree that root-end cavity preparation with US tips has several advantages and facilitates technical operation. Although the risk of microfractures is discussed in their studies, it has not been confirmed whether they are caused by the use of US tips or by one or more of the different steps of the methods used to evaluate in vitro studies. Microfractures and fractures after root-end preparation are a controversial issue, and it is still unknown whether they affect treatment success.

Therefore, further in vivo studies should be conducted to reach a conclusion about whether US tips have a better performance than rotary instrumentation in the preparation of root-end cavities.

The success of this technique was reported by Sumi and others [23] in 1996, in a study that found healing in 92.4% of the root-end cavities prepared with US tips at 3 years of follow-up. In 1997, the same author [24] published another study that reported that all patients evaluated showed healing and adequate repair at one to 12 months of follow-up.

Bader and Lejeune [25] conducted a one-year study with patients to compare the use of burs in a handpiece and US tips, either combined or not with the use of CO_2 laser. They concluded that the use of US alone had a success rate of 90%, whereas the rate for the conventional technique was 65%. They also reported that the use of CO_2 laser did not show any statistically significant differences.

After 14 months, Rubinstein and Kim [26] found a success rate of 96.8% of the cases that they studied, and all teeth had fully formed lamina dura on radiographs. The authors assigned these results to the use of US tips in combination with a surgical microscope and micromirrors, which provide greater removal of contaminated tissue and better and detailed visualization of the surgical field.

In 1999, Testori and others [27] published their first longitudinal study, which covered 4.6 years. They found complete success in 85% of the cases treated with US tips, and in 68% of those treated with the conventional technique. In the same year, Von Arx and Kurt [28] obtained 82% total success after one year when using sonic tips, but only 4% of the cases were classified as failures. The authors assigned a lower chance of intradentinal microfractures to the use of sonic instrumentation, which, however, removed less debris than US tips. The evaluation of in vivo studies should take into consideration tooth shape and anatomy. Greater success rates are found for maxillary and anterior teeth. Operator variables and several patient characteristics should also be taken into consideration, as well as the difficulty to standardize radiographs in clinical studies.

Reports in the literature show the improvements brought about by the use of US tips. This procedure is much more conservative because a smaller osteotomy is necessary for apical access. Moreover, the apicoectomy may be performed at a 90-degree angle, which preserves root structure and, at the same time, removes the greatest amount of accessory canals in the apical delta. Root-end cavities with a mean depth of 3 mm ensure retention of root-end filling material and avoid excessive dentin removal and root perforations, which are sometimes inevitable when the conventional technique is used. Root-end cavities are cleaner because of irrigation and tip vibration, and the removal of smear layer and debris ensures better adaptation of root-end filling materials.

Their greater ease of use is also confirmed, and may be summarized as more accuracy and safety, and less operation time and surgical stress.

CONCLUSION

The success of periradicular surgeries depends on the type of cavity prepared, and the use of US tips results in cavities that are prepared with less removal of dentinal structure and that are well shaped for root-end filling with dental materials. Moreover, it provides easier surgical access and a more refined technique with better clinical results.

Utilização de ultra-som em cirurgia parendodôntica

Resumo

O avanço tecnológico incrementou os índices de sucesso de procedimentos odontológicos. Em cirurgia parendodôntica, retropontas ultra-sônicas proporcionam uma retrocavidade de qualidade superior e permitem uma apicectomia em 90 graus, removendo maior quantidade de tecido contaminado. Os autores realizaram uma revisão de literatura da técnica in vitro e in vivo; procederam à análise de retrocavidades feitas com broca e retroponta ultra-sônica, com auxílio de macrofotografias digitais e Microscopia Eletrônica de Varredura.

Palavras-chave : Endodontia; Cirurgia parendodôntica- Procedimentos; Apicectomia.

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Recebido em / ***Received***: 11/12/2007
Aceito em / ***Accepted***: 07/03/2008