Original Article: In Vitro Evaluation of Effect of Supporting Bone on Preventing Cracks in Roots Resected by Ultrasonic and Bur

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ABSTRACT

Introduction & Aim: The problem of crack formation during apical cavity preparation is one of the current challenges of endodontic problems. The purpose of this study was to investigate in vitro evaluation of effect of supporting bone on preventing cracks in roots resected by ultrasonic and bur. **Materials and Methods:** In this experimental study, 113 single-rooted human teeth with single canal and direct root were examined in the control group (40 teeth) and the experimental group (73 teeth). To evaluate the number of canals and the curvature of the root, P.A digital radiographs were prepared from buccolingual and mesiodistal directions. All teeth were evaluated for surgical microscopy in terms of crack, external analysis, and any defect. In all samples, the apical cavity was provided with diamond burs and a spray of air and then irrigated with sodium hypochlorite. In the control and experimental group, the samples were divided into two groups with of supporting bone and no of supporting bone. Each group was again divided into two subgroups (A, B). Then from the 3 mm apical portion of the roots, it was cut off by bur (subgroup A) and ultrasonic (subgroup B). The cut surface was examined by endoscopy microscope for presence or absence of crack. **Results:** All samples with supporting bone in both groups were free from cracks by ultrasonic and bur. In endodontic roots, without supporting bone, 92.86% in bur method and 90% in the ultrasonic technique, lacked cracks. In the control group, without bone support, 20% in the bur method and all the samples in the ultrasonically free of cracks. **Conclusion:** Supporting bone prevents cracking in endodontic roots by ultrasonic and bur.

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Introduction

The aim of root cavity preparation techniques during endodontic surgery is to prepare a well-prepared cavity and finally to fill this apical cavity with various materials that guarantee flooding of this area. Ultrasonic retro type has shown several advantages compared to the traditional hand piece used in endodontic surgery. This way; It has the ability to prepare a cavity along the longitudinal axis of the channel and maintain the morphology of the channel. Apical cavities may be prepared more easily, safely and accurately than the traditional hand piece method. In addition, reducing the angle of the bowl of the end of the cut root, which will be completely perpendicular to the longitudinal axis of the canal. This feature has the advantages of reducing the number of open dentinal tubules and minimizing apical leakage. Cutting the apical part of the root and preparing the cavity at the end of the cut root with the help of ultrasound is performed during apical surgery, which is usually accompanied by cracks in the root dentin (5). The problem of detecting cracks is one of the current challenges and problems of endodontics. A large number of researchers who have evaluated the cut and separated tooth root before and after tooth root preparation have presented different results (6-8). Layton and colleagues described three types of cracks: canal cracks, intra dentinal cracks, and semental cracks (9).

These hairs are described as complete or incomplete depending on how far they reach the outer surface of the root. Channel cracks originate from inside the channel. They are only limited to the dentin and the semental hairs extend from the semental to the semental-dentin junction (10). Researchers have found that 18% of the roots crack after removing the apical part of the tooth root, and 43% of them occur after the preparation of the cavity at the end of the tooth root using ultrasonic tips (11). Sunders and his colleagues observed that 21% of the roots cracked after preparation of the cavity of the end of the cut root with a bur with a sharp round and ultrasonic tip (12). The use of ultrasonic and related tips for the preparation of the cavity of the end of the root is widely accepted and has advantages including small dimensions and better access to the cavity of the end of the cut root (13). It has been shown that the cavity prepared at the end of the root with ultra-sonication leads to the creation of cracks in the wall of the severed root (14). Also, Abedi et al. compared the effect of the cavity prepared at the end of the root cut by bur and ultrasonic and concluded that bur significantly creates less crack than ultrasonic (15).

Waplington et al found no significant difference between burs and ultrasonic. Although they observed more chipping in the root dentin cut with ultrasonic (16). Studies have shown that the use of high-power ultrasound to prepare the end cavity of the root causes more cracks compared to medium and low power (17). In another study, they did not observe such a difference (18). In another study, Aydemir and his colleagues conducted a study in 2014 between burs and lasers in terms of cracking and did not find any significant difference between these two devices (19). It is assumed that the periodontal ligament and alveolar bone have a protective role on the root and prevent hair loss. This is while all these studies have focused on the wall of the root canal and the possible crack in it, and a study that shows the effect of burs or ultrasound on the root covered with periodontal ligament and bone or the root that is surrounded by bone. It will be out of date and not available. Therefore, in this study, the investigation and comparison of bur and ultrasonic in creating cracks in roots with and without bone support was done.

Review of texts and articles

Pre radicular surgery has two goals. The first goal is to remove the etiological agent, and the second is to prevent re-infection of the pre radicular tissue after the removal of the etiological agent (20). Etiological factors are usually classified under groups including bacteria inside or outside the root, chemical substances inside or outside the root, or physical factors outside the root (21). The only definitive way to eradicate such stimuli is to physically remove them by cutting off the end of the root. Also, the goal of pre radicular surgery is to prevent re-infection of tissue after removing etiological factors (22). If it is not possible to completely clean the rest of the canal system from stimuli, this can only be achieved when a root end filling material is placed to block the residual stimuli inside the prepared cavity at the end of the root to prevent re-contamination of the pre radicular tissue. (23). Preparing a hole at the end of the root is one of the basic steps of establishing an apical flood. The goal is to create a hole at the cut end of the root, which is large enough to place the filling material at the end of the root, and at the same time prevent unnecessary damage to the tooth structure. Surgery is most successful when the rest of the canal system is well cleaned and shaped to remove microorganisms and irritants (5). Conventionally, a micro hand piece with a rotary bur was used for this purpose, which created several problems for the surgeon during the treatment, which were:

1. It was difficult to reach the end of the root, especially when space was limited.
2. There was a higher risk of perforation of the lingual surface of the root due to failure to follow the main route of the canal.
3. There was insufficient depth and the problem of the filling material remaining at the end of the root in the cavity.
4. Cutting with an angle at the end of the root would expose more dentinal tubules.
5. The isthmus and its necrotic tissue could not be accessed and removed.

Richman first used ultrasound in endodontics in 1957. He used modified periodontal ultrasound for debridement and epichoectomy (27). After that, Carr introduced the retro type shape, which was specifically designed to prepare the cavity of the end of the root during surgery. Today, the preparation of the end of the root is often done with ultrasonic technique (28). The use of pen and ultrasonic type has become widely popular because it has many advantages. Due to its small size, there is no improvement in access to the end of the cut root, and there is no need for a drill to create a hole, or a minimum drill is needed (13, 3).

Also, the number of exposed dentin tubules is minimized and the prepared cavity is smaller and cleaner, the depth of the prepared cavity and its grip is suitable, and the prepared cavity is parallel to the longitudinal axis of the tooth (29-31). Working with the ultrasonic type has a significant advantage in cases where there is osmosis because the possibility of root perforation is reduced and the osmosis can be removed (32, 33). Most of the ultrasonic types that were used in the beginning were made of stainless steel. But recently, ultrasonic surgical tools covered with diamonds were introduced and the purpose of their use was to increase the ability of these tips to cut dentine, which reduced the time of preparation of the cavity and contact of the tip with the dentine, and the possibility of cracking was reduced (4). Several studies compared the diamond-coated tip with the stainless-steel tip, which did not differ in terms of crack formation. However, the type covered with diamond caused root tip cavity faster (36-34).

Recently, types covered with zirconium nitride, such as the KIS type, have been introduced (24). In the diamond-coated tip, the diamond particles stuck to the surface of the tip and increased the thickness of the tip of the device, but the zirconium nitride particles penetrated into the tip and the device was thinner than the diamond-coated tips (35). The negative point of the type covered with zirconium nitride was its inability to remove gutta-percha from the root canal, and the reason for that was the relatively smooth surface of the device (35). Navarre compared the KIS tip with the stainless steel tip in terms of gutta-percha removal and concluded that the KIS tip removes the gutta-percha from the axial wall of the canal and the ideal cavity of the end of the root is created with the KIS tip faster than the stainless steel tip (37). In a study, Suanders et al pointed out for the first time that the crack created on the surface of the root is cut when the cavity of the end of the root is prepared with an ultrasonic type, more than when a process bur and a hand piece with a slow rotation of the root are used for this purpose (12).

Frank et al. investigated the effect of 5 different methods of preparation of root cavity. For this purpose, in 60 extracted human teeth, 2-3 mm of the root end was cut and with 16 times magnification the presence of fracture line after methylene blue staining was investigated. The following was used to prepare the cavity of the end of the root. In the first group, a trend bur and hand piece were used at high speed, and in the second group, a trend bur and hand piece were used at a slow speed, and in the third group, a sonic hand piece was used. In the fourth and fifth groups, the ultrasonic method with medium and high intensities of the device was used to prepare the cavity, and again after methylene blue staining, the samples were examined with a magnification of 10. The most crack was in the group where the cavity of the end of the root was prepared with an ultrasonic device and high intensity of the device. Also, crack was more in concave roots than round and spindle-shaped roots (17).

In their study, Waplington et al investigated the changes in the root surface following the preparation of the cavity of the end of the root with the maximum intensity of the ultrasonic device and the method of preparing the cavity with a bur. For this purpose, 55 extracted human teeth were prepared and filled with gutta-percha and sealer. Then 3 mm of the end of the root was cut perpendicular to the longitudinal axis of the tooth and a 3 mm deep hole was created at the end of the root using a bur or ultrasonic and the samples were examined for the presence of cracks or chipping. There was no significant difference regarding the creation of crack in the samples, but chipping was more during the use of ultrasonic than bur (16). Regarding the effect of ultrasonic intensity on creating cracks during cavity preparation, Layton et al. concluded that the use of higher ultrasonic power during preparation of the root end cavity creates more cracks compared to medium and low power (9). Frank also obtained a similar result in his study (17). However, due to the main problem of this method, which is the possibility of creating a crack, the study continued to find a new method of preparing the cavity of the end of the root.

Chaudhry et al in 2016 conducted a study with the aim of finding root cavities prepared using laser and ultrasonic retro type and conventional burs. About 60 single-rooted teeth were selected. Class I cavities with a depth of 3 mm were prepared using three methods. The results showed that the marginal chipping of cavities prepared using ultrasonic was significantly higher than bur or laser, and the laser group had the lowest amount of chipping. Examining the number of cracks showed that 7 samples in the milling group and 3 samples in the laser group had cracks in the ultrasonic.

There is a significant difference between the number of cracks created by these three methods (38). Arslan et al.: YSGG paid. For this purpose, retrograde cavity was created in 60 root canals by 6 methods. The first group: Ultrasonic, the second group: 3.5 W laser, 30 Hz, the third group: 3.5 W laser, 20 Hz, the fourth group: 4 W laser, 30 Hz, the fifth group: 4 W 20 Hz laser and the sixth group: High-speed milling top.

Cracks were examined using a stereomicroscope in three areas: Cementum, dentin and canal wall. The results showed that the most cracks were in the seminoma and the least in the canal wall. In the first category, ultrasonic and then milling had the most cracks. The number of cracks in groups 2, 4, and 3 was similar, and it was also similar in groups 3, 5, and 2 in the three investigated areas. But there was a significant difference in the number of cracks between groups 4 and 5 in the dentin area. According to the results of these researchers, ultrasound was the most invasive root preparation technique. The laser with 4 W 20 Hz had the least amount of cracks. In this study, power adjustment (laser) had little effect. When groups 2 and 4 (values of 3.5 and 4 W respectively) were compared, only a small number of dental cracks were observed. When the values of groups 3 and 5 (3.5 and 4 W, respectively) were compared, no significant difference was observed in the number of cracks in cement, dentin and canal wall. However, when groups of the same strength but different frequencies were examined (comparison of group 2 vs. 3 and group 4 vs. 5), a significant difference was found for dental cracks; The higher frequency group (group 4, 30 Hz) had more cracks than the low frequency group (group 5.20 Hz).

In other words, it is concluded that setting the power of 3.5 W or 4 W does not make much difference, but the frequency of 30 Hz increases the risk of cracking (39). In 2013, Aydemir et al investigated and compared the presence of cracks after root cavity preparation using two methods of Er, Cr-YSGG laser and ultrasonic retro type. For this purpose, 50 single-rooted maxillary human teeth were used. All teeth are stored in distilled water. The root canal was prepared with Protiper. Washing was done with 2.5% sodium hypochlorite and EDTA. The prepared roots were examined under a scanning electron microscope (SEM) for the presence of cracks. The results showed that in the laser samples there were 1.1±1.07 complete cracks, 1.4±1.04 incomplete cracks and 2.35±1.59 intra dentinal cracks in the ultrasonic group, 0.85±0.9 were complete cracks, 1.5±1 incomplete cracks and 2.45±1.50 intra dentinal cracks.

The results showed that laser and retro type have no difference in reducing complete, incomplete, intra dentinal cracks and the total number of cracks created in the tooth (19). Wallace et al., in a study in 2006, showed that ultrasound is often used to prepare root canals. This method causes cracks on the teeth. In this study, they prepared 36 teeth using waterlase laser, which caused a crack in only one tooth. Therefore, they concluded that the use of laser is more reliable than ultrasound in the preparation of the cavity at the end of the root (7). In 2005, De Bruyne et al. investigated the integrity of the root end during the preparation of root end cavity with medium and low ultrasonic power, which did not observe a significant difference in the amount of crack between medium and low power and the reduction of the device power from medium to low during cavity preparation did not suggest (40). In 2003, Ishakawa et al. investigated the amount of cracks created during root canal preparation using different types of ultrasonic tip (stainless steel tip, diamond-coated tip, and zirconium nitride tip), and the difference between the three methods was not significant. (41).

In 2000, Rainwater et al. investigated the method of preparing root end cavity with conventional ultrasonic drill and diamond-coated drill, and there was no difference between the methods in terms of micro crack (42). Zarrabian et al. conducted a study in 1999 with the aim of comparing and investigating the creation of cracks in the preparation of the cavity of the end of the root using ultrasonic devices. In this study, 85 extracted single-rooted teeth were divided into five similar groups. After instrumentation and canal filling by lateral compression method, about 3 mm were cut from the end of the roots; Root end cavities were prepared in two groups by means of a parasite and a ½ process drill, and in the other two groups with the highest power level of the dents play ultrasonic device and the TFI-10 tip, and in one group with the highest power level of the neo sonic ultrasonic device and the CT-1 diamond tip. The ends of the roots were examined using a stereomicroscope with a magnification of 50 times for the presence of any cracks or changes in the cut surface of the root end. The results of the study showed that the use of high powers of ultrasonic devices to prepare the cavity increases the possibility of cracking in dentin (2). In 1997, Min et al. examined the cavity of the end of the root prepared by ultrasonic or bur. They used 40 extracted human molar roots and after cutting 3 mm from the end of the root, they divided the samples into 4 groups. In one group, he prepared a hole at the end of the root with a depth of 2 mm with a drill, in the second and third group, he prepared holes with a depth of 2 mm with an ultrasonic device with medium and low intensity, and he did not observe a difference in the depth and length of the crack in the four groups under test (43).

Beling et al., 1997, compared cracks created during ultrasonic root canal preparation in intact teeth with those that had their canals prepared and filled with gutta-percha and sealer. In his study, he divided 40 teeth into two groups of 20, and in the first group, canals were prepared and filled with gutta-percha and sealer, and in the second group, canals were left intact. Then, in all the samples, 3 mm of the end of the root was cut perpendicular to the longitudinal axis of the tooth, and the cavity of the end of the root was prepared with an ultrasonic device in all the samples using low intensity of the device. Then, the roots were examined for the presence of cracks with a stereomicroscope and 20 and 30 magnifications, and before that, the samples were placed in methylene blue solution, and there was no significant difference between filled and unfilled tooth samples in terms of crack formation (44).

In 1996, Layton et al., in a study on 30 human tooth roots, showed the effect of using high-frequency and low-frequency ultrasonic retro type in the preparation of the root cavity in endodontic surgery, that the use of high frequency caused more cracks compared to creates the bottom (9).

Abedi et al., in 1995, investigated the effect of root cavity preparation with bur and ultrasonic. For this purpose, they used 47 extracted teeth whose resins were selected as standard and identical. These teeth were filled with gutta-percha and sealer after preparation. After cutting the end of the root, a photograph of the teeth was obtained at a magnification of 30 times. In one group, the cavity of the end of the root was prepared with a bur, and in the other group, an ultrasonic type was used to prepare the cavity of the end of the root, and the samples were examined with SEM in terms of the integrity of the end of the root, and the prevalence of crack in the use of a bur compared to ultrasonic significance was less (15).

Study Type: Experimental

Study population: Human single-rooted teeth

Sample size and its calculation method: A total of 120 teeth, 40 of which are intact and control, and 80 teeth are in the experimental group.

The sample volume is determined using the following formula (7).

$$n=z1-\alpha2+z1-\beta2\times p11-p1+(p2(1-p2)d2$$

Exclusion criteria: Tooth fracture

Inclusion criteria

1. Single root tooth;
2. No fluff;
3. Without analysis and calcification;
4. Without previous root treatment.

Data collection method and tools: Endo surgical microscope and information form

Method

120 single-rooted human teeth with a canal and straight root were selected. These teeth were obtained from patients aged 16 to 65 due to periodontal diseases, orthodontics and prosthetic treatments. These teeth were kept in 0.9% saline and 0.02% sodium azide to prevent the growth of bacteria until the test. The teeth were radiographed from the buccolingual and mesiodistal direction to evaluate the number of canals and root curvature by digital P.A radiography. All teeth were evaluated by an endodontic specialist for the presence of hair, external analysis and any defects by a surgical microscope. The samples were kept moist during the examination to prevent the possibility of cracking in a dry environment. The teeth were randomly divided into 2 groups, instrumented and non-instrumented, so that 40 teeth were in the non-instrumented group and 80 teeth were in the instrumented group. The samples of the instrumented group were prepared by a 12th semester dental student (constant assistant) using a standard method using a high-speed turbine fissure bur with air and air cooling to prepare the cavity and the canal of each sample using the crown-down method using the Edge Taper Platinum F2 file. Edgendo American size 25 was prepared with 8% tipper along with 5.25% sodium hypochlorite detergent. The working length was determined by placing K File No. 15 inside the

canal and viewing the tip of the file from the end of the root and reducing it by one millimeter and confirmed by digital periapical radiography. Preparation with Edge Taper Platinum F2 files was performed during the operation, then the canals were washed with 5 cc sodium hypochlorite 5.5% and 5 cc EDTA 17% (meta biomed korea) to remove the smear layer. After completing the instrumentation and washing, the canals were filled with dry sterile paper canals and with gutta-percha and AH plus sealer using the lateral compression technique. Then the gutta-percha was cut from the orifice of the canal and the remaining gutta was compressed inside the canal by a burnisher or condenser. The samples were placed in wet gauze until the sealer hardened for a week. A piece of the sheep's mandible bone was separated and inside the sheep's jawbone, a hole was first made in the area of the lower alveolar canal perpendicular to the ossify able external surface to create an artificial bone lesion. Then, along the longitudinal axis of the teeth, another cavity was made perpendicular to the primary cavity so that the studied teeth are placed in this cavity. In order to rebuild the periodontal ligament, Spadex Wash was prepared and after mixing, it was poured into the cavity and the teeth were immediately placed inside the cavity.

About 5 mm of the apex of the teeth was visible in the lower cavity (without bone support) and in the group with bone support, the teeth were mounted so that 3 mm of the apex of the root was visible in the lower cavity. The control group is divided into four groups of ten, and we cut 3 mm of the end of the root with a bur and ultrasonic. The samples were divided into two groups with bone support and without bone support. Then each group was again divided into two subgroups. In subgroup a) 3 mm, the apical part is cut with a bur and in subgroup b) The apical part is cut with ultrasound. After cutting the end of the root, the cut surface was checked with an endo microscope for the presence or absence of hair. In the experimental group, 80 samples were examined, and 7 samples (1 sample with bone support and 6 samples without support) were excluded from the study.

Data analysis and description method

Data analysis was done by SPSS 20 software. Data analysis was analyzed by frequency and frequency percentage in each group. Fisher's test has been used to compare the two methods of ultrasonic and milling, as well as to compare groups.

Findings

In this study, 120 samples were examined, seven samples with cracks were excluded from the study, so that 40 samples were in the control group and 73 samples were in the endoscopic group. In each of the control and test groups, the samples were examined in 4 ultrasonic and bur groups with and without bone support.

Objective 1: What is the frequency distribution of cracks in intact roots with bone support and cut with ultrasonic?

Table 1. Frequency of cracks in intact roots with bone support and cut with ultrasonic

Percent	Number	
100	10	Without crack
0	0	Cracked
100	10	Total

10 intact root samples (control) with bone support were cut by ultrasonic method, and all samples had no cracks.

Objective two: What is the frequency distribution of cracks in intact roots with bone support and cut with a bur?

Table 2. Frequency of cracks in intact roots with bone support and cut with a bur

Percent	Number	
100	10	Without crack
0	0	Cracked
100	10	Total

10 intact root samples (control) with bone support were cut by milling method, and all samples had no cracks.

Objective three: What is the frequency distribution of cracks in intact roots without bone support and cut with ultrasound?

Table 3. Frequency of cracks in intact roots without bone support and cut with ultrasound

Percent	Number	
100	10	Without crack
0	0	Cracked
100	10	Total

10 intact root samples (control) without bone support were cut by ultrasonic method, and all samples had no cracks.

Objective four: What is the frequency distribution of cracks in intact roots without bone support and cut with a bur?

Table 4. Frequency of cracks in intact roots without bone support and cut with a bur

Percent	Number	
80	8	Without crack
20	2	Cracked
100	10	Total

10 intact root samples (control) without bone support were cut by bur method, 80% of the samples were without cracks and 20% had cracks.

Objective five: What is the frequency distribution of cracks in roots endodontic with bone support and cut with ultrasonic?

Table 5. Frequency of cracks in roots endodontic with bone support and cut with ultrasonic

Percent	Number	
100	19	Without crack
0	0	Cracked
100	19	Total

19 endodontic root samples with bone support were cut by ultrasonic method, and all samples were without cracks.

Objective 6: What is the frequency distribution of cracks in the roots endowed with bone support and cut with a bur?

Table 6. Frequency of cracks in roots endodontic with bone support and cut with a bur

Percent	Number	
100	20	Without crack
0	0	Cracked
100	20	Total

20 endodontic root samples with bone support were cut by bur method, and all samples were without cracks.

Objective Seven: What is the frequency distribution of cracks in endodontic roots without bone support and cut with ultrasound?

Table 7. Frequency of cracks in endodontic roots without bone support and cut with ultrasonic

Percent	Number	
92.86	13	Without crack
7.14	1	Cracked
100	14	Total

13 endodontic root samples without bone support were cut by ultrasonic method, 92.86% of the samples had no cracks and 7.14% had cracks.

Objective 8: What is the distribution of the frequency of cracks in endodontic roots without bone support and cut with a bur?

Table 8. Frequency of cracks in endodontic roots without bone support and cut with a bur

Percent	Number	
90	18	Without crack
10	2	Cracked
100	20	Total

13 endodontic root samples without bone support were cut by bur method, 90% of the samples had no cracks and 10% had cracks.

Objective 9: There is a difference between the above groups in terms of creating cracks.

Table 9. Frequency of cracks in endodontic and control roots, with and without bone support and cut with ultrasonic and bur

All samples with cracks	No support (%) n			With support (%) n		Root cutting method	Root type
	P value	Cracked	No cracks	Cracked	No cracks		
1(3.03)	0.635	1(7.14)	13(92.68)	-	19(100)	Ultrasonic	Endowed root
2(5088)		2(10)	18(90)	-	20(100)	Bur	
-	0.237	-	10(100)	-	10(100)	Ultrasonic	Control
2(10)		2(20)	8(80)	-	10(100)	Bur	
		0.819		-		P value*	

P value: Fisher's test for comparing two ultrasonic and milling methods (without support).

P value*: Fisher's test to compare smoking in 4 groups.

Analysis of the results

Endowed roots: with bone support, all samples have no cracks in both ultrasonic and bur cutting methods. But without bone support, in the milling method, 7.14% have cracks and in the ultrasonic method, 10% have cracks, according to Fisher's test, there is no significant difference in the amount of cracks in the two methods (P=0.635).

In the control group: With bone support, all samples have no cracks in both methods of root cutting with ultrasonic and bur. But without bone support, in the milling method, 20% of the samples have cracks, but the samples cut by ultrasonic are all free of cracks, according to Fisher's test, there is no significant difference in the amount of cracks between the two methods (P=0.237). In general, in 33 samples in the ultrasonic group (with support and without support), one sample (3.03%) had cracks. In the 40 examined samples in the milling group (with support and without support), two samples (5.88%) had cracks. The comparison of 4 groups (laser and ultrasonic in endoscopic and control) does not show a significant difference in the amount of cracks (P=0.819).

Discussion

In the present study, the total number of samples was 120, of which 80 samples were in the experimental group and 40 samples were in the control group. During the research, 7 samples from the experimental group were excluded from the study due to cracking during canal preparation. The samples were examined in two groups: Laser, ultrasonic and manual milling. So that in the endoscopic group, they were in the ultrasonic and bur groups with bone support and without bone support. The results of this study showed that in the ultrasonic group (with support and without support) 3.03% (one sample) had cracks and in the milling group (with support and without support) 5.88% (two samples) had cracks.

In the present study, in the roots with bone support, all samples had no cracks in both methods of root cutting with ultrasonic and bur. But without bone support, 92.86% in the milling method and 90% in the ultrasonic method had no cracks. According to Fisher's test, there was no significant difference in the amount of cracks between two ultrasonic and milling methods. Waplington and his colleagues (1997) did not find a significant difference between milling and ultrasonic in terms of the presence of cracks (16). The results of these researchers were consistent with the present study. Some studies had different results. Chaudhry et al. showed in 2016 that the frequency of cracks in the ultrasonic method with 35% was significantly higher than the milling method with 15% of cracks (38). In 2013, Arslan et al. compared the frequency of cracks in the three methods of laser, ultrasonic, and milling, and found that ultrasonic and then milling had the highest number of cracks (39). One of the reasons for the difference in the results can be attributed to the grade and strength of the examined devices, the time of use of the device, the presence or absence of early cracks and the thickness of the dentin around the cavity. Zarrabian et al. showed in 1999 that the use of high powers of ultrasonic devices to prepare the cavity increases the possibility of cracking in dentin (2). However, some studies do not consider the type and power of ultrasonic to be effective on the amount of cracking. Ishakawa et al. (2003) stated that the amount of crack created in different types of ultrasonic type was similar (41). Rainwater et al. (2000) did not show a difference in terms of micro crack between the conventional ultrasonic type bur and the diamond-coated type (42). De Bruyne et al. (2005) did not observe a significant difference in the amount of crack between medium and low strength (40). The ultrasonic tips are non-cutting and work by making gutta-percha and vibrating action using Thermoplastics. If the gutta-percha is removed before cavity preparation, less time will be required for ultrasonic cavity preparation and the possibility of cracks will be reduced. Heat carry tip can be used to remove gutta-percha. Due to the greater cutting power of diamond coated tips, the use of these tips reduces the cutting time and thus the chance of cracking (33). Due to the high cutting power of the diamond tips of the p-5 ultrasonic device, it is possible to use the lower powers of the device with sufficient efficiency to prepare the cavity, which also reduces the formation of cracks. TFI-10 ultrasonic tips are smooth tip type.

For this reason, their cutting power is less than diamond tips and more time will be required to prepare the hole. Due to the high cutting power of the p-5 device and its diamond tips, vibrations and side movements of the operating hand can easily change the shape of the cavity. Inevitably, the shape of prepared holes is irregular. Therefore, in preparing the cavity with a trend bur or diamond tips, applying force around can expand the cavity in one direction, but the shape of the cavity cannot be easily changed with the dents play ultrasonic device with smooth tip (7). Considering that the cracks created after the preparation of the cavity by TFI-10 pen tip are mostly due to the pressure applied to the canal walls and through the operator's hand and not due to the impacts caused by the vibration of the device, by making the tips smaller and finer, and the use of tips smaller than the cross section of the canal to prepare the cavity, most likely, the amount of cracks created after the preparation of the cavity at the end of the root will be much less or even zero. Of course, it is better to make and standardize a series of different tips with different sizes and then use them with the dent splay device and study them (2).

Conclusion

In the present study, the number of cracks observed in the control samples (10%) was higher than that of the endoscopic samples (8.91%), it can be concluded that the occurrence of cracks in the samples can be an independent incident of root cutting. On the other hand, the storage and extraction conditions of the teeth used in the study may cause micro cracks on the root surface. For this reason, the teeth used in this study were examined using a stereomicroscope and the teeth were removed by cracking before the study. Also, the teeth were kept in moist conditions to prevent drying. The results of the present study showed that both ultrasonic methods and bone support milling did not affect the rate of cracking. Another important point that seems to play a role in the occurrence of cracks is the support of the tooth by periodontal fibers, which act as a cushion in weak traumas to the tooth and neutralize their effect on the tooth with their flexibility. Periodontal tissues remove some of the pressure that the root takes during instrumentation and preparation of the exposed cavity and increases the resistance to crack formation. Therefore, it seems that the ideal method of investigation is to conduct research on living organisms and animals.

- Ultrasonic group with bone support, all samples had no cracks.
- The bur group with bone support of all samples had no cracks.
- The ultrasonic group without bone support had no cracks in 90% of the samples.
- 92.86% of samples without bone support in the milling group had no cracks.
- In the ultrasonic control group (intact root), all samples with and without support had no cracks.
- In the control group (untouched root) of bur, all samples with support had no cracks and without support, 20% of the samples had cracks.

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