

Evaluation of three different spreading forces using lateral condensation technique on apical leakage and tooth fracture: an in vitro study

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Abstract

Background and Aim: Lateral condensation technique is one of the most frequently used techniques for root canal obturation. There were few studies in order to determine the needed force for spreader penetration and its effect on apical seal. The purpose of this study was the in vitro evaluation of the effect of three spreader forces using the lateral condensation technique and the effect of these forces on root fractures.

Materials and Methods: Eighty-five human mandibular premolar single rooted teeth without severe curvature and visible fractures were chosen and randomly divided into three groups. Following canal preparation, all samples were obturated on an acrylic model using three forces (1.6, 3 and 4.5 kg) with the lateral condensation technique. The teeth were observed under the stereomicroscope $\times 6$ for any fracture line and follow the clearing of the teeth the maximum dye leakage penetration was measured for each tooth. The data were analyzed by using chi-square and Kruskal-Wallis statistical tests.

Results: All samples in the positive control group showed dye leakage but in the negative control group no sample showed any leakage. The mean dye penetration for the first (1.6 kg), second (3kg) and third (4.5 kg) groups was 0.344 mm, 0.153 mm and 0.746 mm, respectively. The 3kg force for lateral condensation technique produced a significantly better apical seal and less leakage in comparison with the other groups ($P < 0.05$) and more fractures were observed with 4.5kg force ($P < 0.05$).

Conclusion: The best force for lateral condensation in premolar teeth was 3kg and more pressure could produce more fracture.

Key Words: Lateral condensation - Spreader - Leakage - Root fracture

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Introduction

The objective of root canal therapy is extraction of the infective contents and three dimensional filling of the root canal so that an appropriate seal is obtained against fluid leakage throughout the canal length from the coronal to the apical area. The evaluations performed have shown that incomplete filling of the canal and apical microleakage are the main reasons for failure in root canal treatment [1-3]. The lateral

condensation technique is one of the most accepted technique that has been extensively taught and performed by technicians. This technique is simple and easy, needs plain tools and is appropriate for many of the root canal preparations [4]. One of the disadvantages of this method is the inability to fill canals with severe curvatures, open apices and canals with internal resorption [5] in which spreaders are the main tools for filling the canal.

The risk of root fractures in the process of Root canal filling due to forces beyond limit strength to the spreader has been demonstrated in different studies [6].

Spreader is available as manual and digital [7]. Digital spreaders are better than the manual ones due to their better apical seal, better control of the tool and decreasing the pressure to the dentin at the time of filling. Digital spreaders decrease the possibility of vertical root fractures during filling and the length of entrance into the canal is deeper than the manual spreaders [5]. In addition to the design of the spreader, the material the spreader is made up of is another factor leading to vertical root fractures [8]. After designing nickel titanium spreaders the entrance force throughout lateral condensation was less compared to stainless steel spreaders [9].

In 1979, in a study conducted by Allison, in all standard preparation of the canals, penetration depth 1 mm of working length of the spreader into the canals resulted in the best apical seal in comparison to less penetrations [10]. In a book written by Torabinejad, 1 mm primary penetration of the spreader has been suggested too [5].

The entered force to the spreader also has to be appropriate and based on Schmidte's report, the clinician has to apply the relevant force to the spreader in order to penetrate it to the appropriate depth of 1 mm [9]. In 1980, Meister reported that 85% of the vertical root fractures are the result of additional applied forces during the lateral condensation technique [11]. There has been few studies regarding the effect of different forces applied to the spreader on the quality of the apical seal in the lateral condensation technique and the aim of this in vitro study was to evaluate the effect of these forces on the root apical seal and to evaluate the probable root fractures.

Materials and Methods

Eighty five human single canal mandibular pre-molars with a complete apex, no severe

curvatures and no observed cracks or fractures were chosen for this experimental laboratory study. Periapical radiography—both buccolingually and mesiodistally—was used to find out whether the samples had a direct and single canal, calcification and internal corrosion.

First of all, the crown of all the samples were removed 3 mm below the cemento-enamel junction (CEJ) by a narrow cone shaped diamond bur (Teledyne Densco) and water and air spray.

In order to estimate the canal length, a number 15 K file (Mani, Japan) was entered into each canal in a way that the tip of it was seen in the apex area; subsequently, to obtain the canal's working length 1 mm was subtracted from the above mentioned length measured by the K file. Afterwards, the apex of all the samples were prepared until a file #25 which was named the master apical file and the upper part of the canal was prepared by using stepback technique until a file #35 and then followed with Gate Glidden 2 and 3. Finally, a rotary Protaper F2 file (Mailefer, Switzerland) was used to standardize the apical size measure of the prepared canals. After preparation of the canal and before obturation, to evaluate the probable fracture, the samples were evaluated by Ziess stereomicroscope 6× magnification. In case a fracture was detected, the sample was replaced with a sound one.

Consequently, the prepared teeth were randomly divided into five groups. Three groups each consisting of 25 teeth were chosen as the experimental groups and two groups each with five teeth were selected as the positive and negative control groups. The experimental samples were embedded in distilled water. After drying the canal, the samples were obturated by a stainless steel 25 spreader (Mani, Japan) with three different forces, 0.5 mm shorter than the working length of the canals using the lateral condensation technique with GuttaPercha (Ariadent, Iran)

and Tubliseal sealer (Kerr, America) according to the below mentioned illustration.

In order to determine the force applied to the spreader, the teeth were put into an acrylic block and the whole collection was placed on a digital powermeter (SOEHNLE, Germany) with 0.1 kg accuracy (Figure 1).



Figure 1. The designed acrylic model and the tooth placed in optosil together with the spreader

An acrylic cone-shaped block with a four-sided section surface was built in a way that one of the four sided surfaces was larger than the other and this surface was considered as the haven. The smaller surface had a tooth-shaped place in which the samples were put during the obturation. Besides, to conform the different roots and the place on the acrylic block, aptosil paste was used. optosil paste was placed in the location and the root was faced to it until being arranged. Aptosil acted as a pad preventing any destructive and additional force from the acrylic block to the tooth. This pad acts as a periodontal ligament (PDL). In addition each tooth based on its size was conformed with the pad. The teeth were placed on the powermeter as mentioned and when the force was applied simultaneously the force was applied to the powermeter too and the operator was able to measure the force to the sample.

Group 1: In this group the entered force to the spreader till the tip of it reached to 1 mm of the work length was recorded for all the samples.

The mean force was 1.66 kg which was the minimum test force.

Group 2: The root canal was obturated with a two-fold force compared to group 1 (3 kg).

Group 3: The root canal was obturated with a three-fold force compared to group 1 (4.5 kg).

Group 4: This group was considered as the positive control group. It was obturated with a Gut-taPercha #30 without sealer. This group was for reliability of dye penetration into the canal in the testing condition.

Group 5: This was the negative control group in which after preparation the canals were not obturated, but were covered by two layers of nail polish and one layer of wax glue. This group was being evaluated regarding the ability of nail polish and wax glue on the other root surfaces in the test groups.

After canal obturation, all the samples were evaluated regarding the quality of obturation by radiography. The three test groups and the positive control group were put in 100% humidity and 37°C for 72 hours in the incubator; subsequently, the teeth were covered by two layers of nail polish except for the terminal 1 mm. Then all the teeth were put in room temperature for 72 hours in pelikan ink in the vertical position so that 3 mm of the crown was out of ink. The next step was rinsing the teeth with water for 1 minute and then wiping the nail polish with acetone and cotton wool balls. The teeth surface were then evaluated by Zeiss stereomicroscope 6× magnification for fracture and the numbers were recorded in different groups. In order to evaluate dye penetration in the teeth and comparison of the samples, the teeth were cleared by the Tagger method. The samples were observed by Zeiss stereomicroscope 6× magnification with an accuracy of 0.1 mm. All the results were read and recorded by three persons separately in the prepared forms. Every tooth was rotated under the stereomicroscope so that the region with maximum linear permeability was defined and measured by a special liner with 0.1 mm

accuracy and recorded in the related form for that tooth. Fracture analysis was carried out by Chi square test and paying attention to the number of samples in each group and the abnormal distribution of the amount of dye penetration variable, Kruskal Wallis nonparametric test and Dunn test were used. Dunn test which is the complementary test for Kruskal Wallis test was used to define the groups which had significant difference regarding microleakage.

Results

In the positive control group all the samples showed dye permeability, but in the negative control group no dye permeability was detected. The mean permeability in the first group (1.6 kg force), the second group (3 kg force) and the third group (4.5 kg force) was 0.344 ± 0.0284 mm, 0.153 mm and 0.153 ± 0.0209 mm, respectively. In the comparison carried out by statistical tests, the dye penetration in the second group (3 kg force) compared to the other two groups showed the least leakage which was statistically significant ($p=0.021$). In addition, tooth cracks and fractures were evaluated after canal obturation. In the first group (1.6 kg), one cracked tooth (4%) was detected under the microscope. In the second (3 kg) and third groups (4.5 kg) four (16%) and 12 (48%) cracked teeth were observed, respectively.

The statistical Chi square test was chosen for analysis of the fractured teeth. Based on this analysis, a statistical significant difference was observed between group 3 and the two other groups ($p=0.01$). Meaning that under 4.5 kg force, in comparison to the other two groups, a greater number of teeth were cracked and fractured.

Discussion

The lateral condensation technique is the most common method used by the dentists for educative and treatment means in dental schools [5]. Nowadays, evaluation of dye penetration is

the easiest and most common method used for microleakage detection of root canal obturation. This method may show the qualification of apical seal and the probability of percolation indicating its value regarding these matters [12]. We have also used this method in the present study. Some researchers have mentioned that the type of dye may influence the quantity of microleakage. Tames et al.'s study showed there is no difference between different dyes regarding microleakage; therefore, calligraphy society pelikan ink was used [13].

Studies have shown that the clinicians should apply the appropriate force to enter the spreader to 1 mm depth of the canal's working length [9]. Allison believed that with such spreader penetration (1 mm) the best apical seal is obtained (10,14). Parirokh et al. also showed that a higher spreader penetration in the lateral condensation technique leads to a better apical seal [15]. The spreader force that causes such penetration (1 mm) is the subject that has been mentioned in other studies. Saw, Harvey and Holcomb have estimated a 1-3 kg vertical force applied by the spreader in the lateral condensation technique [6, 16, 17]. In the present study, in accordance to other studies, a 1 mm penetration depth of the spreader with a 3 kg force obtained the best apical seal. It seems logical that increasing the force leads to better compaction of GuttaPercha in the canal; subsequently, decreasing the space between GuttaPercha cones and increasing the apical seal. Thus, increasing the force should increase the apical seal to the extent that it does not lead to tooth fracture. In the present study, there were three applied forces to the spreader; minimum 1.6 kg, 3 kg and maximum 4.5 kg which according to Blum, Lindauer, Saw, Harvey and Dulaimi's study, the 3 kg force applied to the spreader in order to prevent vertical canal fracture seems appropriate [6, 16-20]. In 1987, Holcomb reported that 1.5 kg force may also lead to vertical canal fracture in the lower central teeth. The reason for these

differences may be due to the test stages, type of teeth and type of spreader [17]. In a study conducted by Pitts on the upper anterior and canine teeth, a minimum force of 7.2 kg resulted in fracture of the upper anterior teeth demonstrating that increasing the force increases fracture emphasizing the results of the present study [21]. In our study we used the Finger spreader which according to Simons study causes a better quality of obturation and less microleakage in comparison to D-11-T spreaders. Because we used premolar teeth which have particular dentin thickness, the results which were similar to Harvey and Dulaimi's study may be used for teeth with the root thickness similar to these teeth and for other teeth such as the lower incisors the force applied is mostly effected by the root thickness [16, 20]. It seems logical to obturate canines and incisors of the maxilla with higher forces to reach higher seals and less fractures and on the contrary for mandibular incisors definitely using less force (approximately 1 kg) to reach an appropriate apical seals is necessary [17]. Although the applied force in the lateral condensation technique is important in obtaining a good apical seal, there are other effective factors in this process such as preparation of the canal. Some specialists believe that preparation of the canal by allowing the spreader to enter to 1-2 mm of the apex with minimum force is the best way to reach the appropriate apical seal with the least probability of root fracture [10, 14, 22].

In 2007, Piskin pointed to the fact that the size of the spreader used for the lateral condensation technique is effective in the resistance of the anterior teeth against fracture. Therefore, choosing a spreader bigger than 25 leads to higher fracture [23]. In this study, a 25 spreader was used, but using a force higher than necessary (4.5 kg) with this spreader may also have the ability to fracture the roots. This matter shows that when the spreader reaches the necessary penetration depth with the appropriate force, additional forces may

result in root fracture. On the other hand, Dulaimi showed that the type of canal preparation influences the preparation depth of the spreader, but has no effect on the applied force to the spreader [20]. In the present study, Rotary and Gates were used simultaneously for the necessary penetration of the spreader to 1 mm depth of the apex with the minimum force (1.6 kg). Besides, in this study, by designing and carrying out the aptosil pad model, we tried our best to set the clinical circumstances nearest to Dulaimi's study regarding applying spreader forces and the come and go movement of the spreader [20]. Soros also evaluated the influence of the biomechanical periodontium on the spreader force regarding fracture. He observed that when the incisors are in the mandibular socket or in an artificial socket there is no significant difference and it seems that similarization of the acrylic resin and the moulding material with the natural periodontium in this study is acceptable [24]. Increase in force increases the seal to a point that does not cause tooth fracture. In our study, with a 1.6 kg force, fracture occurred in one tooth, with 3 kg force, fracture occurred in four teeth and by increasing the force to 4.5 kg, fracture occurred in 12 teeth showing significant difference similar to Holcomb's study. These fractures in addition to the applied force were related to the root diameter, the canal diameter, the degree of convergence of the canal and the canal diameter to the overall root diameter.

Conclusion

For canal obturation in the lateral condensation technique to reach the best apical seal in the mandibular premolars or in roots with the same thickness, a 3 kg force is suggested and because different teeth have different dentin thicknesses, this force could be different for the other tooth.

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