Original Article

Evaluation of three different spreading forces on apical leakage and fracture of roots filled by lateral compaction technique: an in vitro study

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Abstract

Background and Aim: Lateral compaction 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 to evaluate the effect of three spreader forces on root fractures.

Materials and Methods: Eighty-five human mandibular premolar single rooted teeth without severe curvatures or 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 lateral compaction technique. The teeth were observed under 6x magnification for the presence of fracture. Apical leakage was evaluated by dye penetration after the samples had been cleared. The data were analyzed by using chi-square and Kruskal-Wallis statistical tests.

Results: 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 compaction technique produced a significantly lower leakage in comparison with the other groups (P<0.05). More fractures were observed with 4.5kg force (P<0.05).

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

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

The Journal of Islamic Dental Association of IRAN (JIDA) / Spring 2012 /24 / (1)

Introduction

The objective of root canal therapy is removal of the infective contents and three dimensional obturation of the root canal so that an appropriate fluid-tight seal is obtained throughout the canal length from the coronal to the apical area. The evaluations performed have shown that incomplete obturation of the canal and apical microleakage are the main reasons for failure in root canal treatment(3). The lateral compaction technique is one of the most accepted techniques that has been extensively taught and performed by clinicians. This technique is simple, needs uncomplicated tools and is appropriate for most 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). Root fractures have been reported by some authors in this technique due to excessive forces applied to the spreader.(6). Spreaders are available in hand and finger
types(7). Finger spreaders are superior than hand
types because they provide better apical seal,
better control of the tool and decreased condens-
sation pressure to dentin. Finger spreaders de-
crease the possibility of vertical root fractures
during obturation and have a deeper penetrate
tion than hand-operated ones(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 penetration force during
lateral compaction was less compared with
stainless steel ones (9).

In 1979, in a study conducted by Allison, in
which all canals were prepared using standard
 technique, better apical seal was obtained
when the penetration depth of the spreader was
1 mm short of working length compared with
shorter penetration depths(10).

The applied force to the spreader also has to be
appropriate and based on Schmidte’s report, the
clinician has to apply a reasonable force to the
spreader in order to penetrate it to the appropri-
ate depth of 1 mm short of working length(9).
In 1980, Meister reported that 85% of the ver-
tical root fractures result from additionally ap-
plied forces during lateral compaction 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
compaction technique. The aim of this in vitro
study was to evaluate the effect of these forces
on the apical seal and to evaluate the root frac-
tures.

Materials and Methods
Eighty five human single-canaled mandibular
pre-molars with mature apices, no severe cur-
vatures and no observed cracks or fractures
were chosen for this experimental laboratory
study. Periapical radiographs – in both bucco-
lingual and mesiodistal directions – were used
to find out whether the samples had a straight
and single canal, and to rule out the pos-
sibility of calcifications or internal resorp-
tions. First of all, the samples were decoronated 3 mm
below the cemento-enamel junction (CEJ) by a
narrow tapered diamond bur (Teledyne, Densco)
under water and air spray.

In order to estimate the canal length, a num-
ber 15 K file (Mani, Japan) was entered into
each canal in a way that its tip was just seen
through the apical area. Subsequently, to obtain
the working length 1 mm was subtracted from
the above mentioned length measured by the K
file. Afterwards, apical preparation was per-
formed up to #25 which was named the mas-
ter apical file and the coronal part of the canal
was prepared by using step-back technique
until file#35 and then followed by Gates
Glidden burs #2 and #3. Finally, a rotary Pro-
taper F2 file (Mailfeier, Switzerland) was used
to standardize the apical size of the prepared
canals. After preparation, the roots were
evaluated for fracture under 6X mag-
nification using a stereomicroscope
(Zeiss Corp, Germany) before obturation.
In case a fracture was detected, the sample was
replaced with a sound one.

Consequently, the prepared teeth were ran-
domly 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 experimen-
tal samples were stored in distilled water. After
drying the canal, the samples were obturated
by a stainless steel #25 spreader (Mani, Ja-
pan) with three different forces, 0.5 mm
shorter than the working length of the canals.
Canals were obturated using lateral compac-
tion of gutta percha (Ariadent, Iran) and Tubli-
seal sealer (Kerr, SybronEndo, Orange, CA)
according to the below mentioned illus-
tration.

In order to determine the forces applied to the
spreader, the teeth were put into an acrylic block
and the whole collection was placed on a digital
strain guage (Soehnle, Germany) with 0.1 kg ac-
accuracy (Figure 1).

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

An acrylic pyramidal block with a rhombooidal cross-section was constructed in a way that one of the four sided surfaces was larger than others and 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, a silicone rubber was used. Silicone rubber was placed in the location and the root was faced to it until being set. Periodontal ligament was simulated by the silicone which acted as a cushion to prevent any destructive force from the acrylic block to the tooth. In addition each tooth based on its size was conformed with the silicone pad. The teeth were placed on the guage as mentioned while being subjected to the force, so the operator was able to measure the force to the sample.

Group 1: In this group the spreader penetration force for all the samples was recorded to be 1.66 kg which was considered as the minimum test force.

Group 2: The root canals were 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 in which obturation was performed with a single cone of #30 gutta percha without sealer.

Group 5: This group was considered as the negative control in which the canals were not obturated, but were covered by two layers of nail polish and one layer of sticky wax. After canal obturation, all the samples were evaluated regarding the quality of obturation by radiography. The test and the positive control groups were incubated in 100% humidity and 37°C for 72 hours. Subsequently, the teeth were covered by two layers of nail polish except for their apical 1 mm. Then all the teeth were vertically put at room temperature for 72 hours in a dye so that 3 mm from each crown was out of the dye. Afterwards, the teeth were rinsed under running water for 1 minute and their nail varnish coatings were removed. The teeth surface were then evaluated by Zeiss stereomicroscope under 6x magnification for fracture. 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 under 6x magnification with an accuracy of 0.1 mm. Results were recorded by three blinded individuals. For each tooth, maximum linear dye penetration was recorded and measured by a special ruler with 0.1 mm accuracy. 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 was used to define the groups which had significant difference regarding microleakage.

Results

In the positive control group all the samples showed dye penetration, but in the negative control group no dye penetration was detected. The mean penetration within 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, 0.153mm and 0.153±0.0209mm, 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, one cracked tooth (4%) was detected under the microscope. In the second and third groups four (16%) and 12 (48%) cracked teeth were observed, respectively.

Chi square test indicated a statistical significant difference between group 3 and the other two groups (p=0.01).

Discussion
The lateral compaction technique is the most common method used by the dentists for educational 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 in this regard (12). Some researchers have mentioned that the type of dye may influence the quantity of microleakage, but Tames et al showed that there is no difference between different dyes regarding microleakage, therefore a calligraphy ink (Pelikan, Iran) was used for this purpose (13).

Studies have shown that clinicians should apply the appropriate force to enter the spreader 1 mm short of the canal working length (9). Allison believed that with such spreader penetration the best apical seal is obtained (10, 14). Parirokh et al. also showed that a higher spreader penetration in the lateral compaction technique leads to a better apical seal (15). The spreader force that causes such penetration is the subject that has been mentioned in other studies. Saw, Harvey and Holocomb have estimated a 1-3 kg vertical force applied by the spreader in the lateral compaction technique (6, 16, 17). In the present study, in accordance to other studies, a 1-mm-short 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 gutta percha in the canal; subsequently, decreasing the space between gutta percha 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, the 3kg force applied to the spreader in order to prevent vertical canal fracture seems appropriate (6, 16-20). In 1987, Holocomb reported that 1.5 kg force may also lead to vertical canal fracture in the lower central incisor 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 maxillary anterior and canine teeth, a minimum force of 7.2 kg resulted in fracture demonstrating that increasing the force increases fracture corroborating the results of the present study (21). In our study we used the finger-type spreader which according to Simons study causes a better quality of obturation and less microleakage in comparison with D-11-T spreaders. Because we used pre-molar 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 tech-
nique 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 short 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 compaction technique is effective in the resistance of the anterior teeth against fracture. Therefore, choosing a spreader larger 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. It 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, Dulai- mi 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 instruments and Gates Glidden drills 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 silicone pad model, we did our best to set the clinical circumstances nearest to Dulaimi’s study regarding applying spreader forces and the in and out movement of the spreader (20). Soros also evaluated the influence of the biomechanical properties of periodontium on the spreader forces 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 differences similar to Holocomb’s study. These fractures in addition to the applied force were related to the root diameter, the canal diameter, the taper of the canal and the ratio of canal diameter to the overall root diameter.

**Conclusion**

For canal obturation in the lateral compaction 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 other tooth.

**References**