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A Novel Hybrid Hand Instrumentation Technique for Root Canal Preparation

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ABSTRACT

Introduction: Preparation of root canal system necessitates both enlargement and shaping of the complex root canal space together with disinfection of the easily accessible and hidden areas. The present article introduces a new manual root canal preparation technique and compares it with passive step-back and step-back regarding some items such as shaping efficacy, maintenance of working length and occurrence of procedural accidents. **Methods and Materials:** This canal preparation technique (Bolourchi Hybrid Technique-BHT) was compared with passive step-back and step-back root through preparation of 30 extracted human mandibular and maxillary molars. Three experienced endodontists evaluated the final radiographies for following items: 1) difficulty of the case 2) shaping efficacy 3) maintenance of working length 4) time of preparation. Two-way ANOVA was used to analyze the data. Multiple comparisons were done using the Tukey's HSD. **Results:** Regarding shaping efficacy and maintenance of working length, BHT group showed significantly higher scores and scores for step-back group were significantly the lowest. The difference between BHT group and passive step-back on these items was not significant. No significant differences were found between the techniques in other assessed criteria except for occurrence of procedural accidents which was significantly higher in step-back group. **Conclusion:** Considering the advantages of this novel technique as well as its comparability to the present routine techniques, it can be considered as an available root preparation technique for teaching in dental schools.

Keywords: Balanced Forced Technique; Hand Instrumentation; Hybrid Hand Instrumentation; Passive Step-Back; Root Canal Preparation; Step-Back

Introduction

One of the most important objectives of endodontic treatment is to clean the canals from pulp tissue and microorganisms and to prepare enough space with an adequate shape for a three-dimensional obturation [1]. Preparation of the root canal system is recognized as being one of the most important stages in root canal treatment [2]. The major goals of root canal preparation include preventing the periradicular disease and/or promotion of periapical healing that is achieved through: removal of vital and necrotic tissue from the main root canal(s), preparation of sufficient space for irrigation and medication [2], preservation of the integrity and location of the apical canal opening [3], avoidance of iatrogenic damage to the canal system and root structure or infection/irritation of the periradicular tissues [4], facilitation of canal filling and preservation of sound root dentine to allow long-term function of the tooth [2, 5].

Several techniques have been proposed for canal preparation that were all created considering pioneer techniques and making some modifications in their modality and instruments. While root canal rotary instrumentations is the center of attention

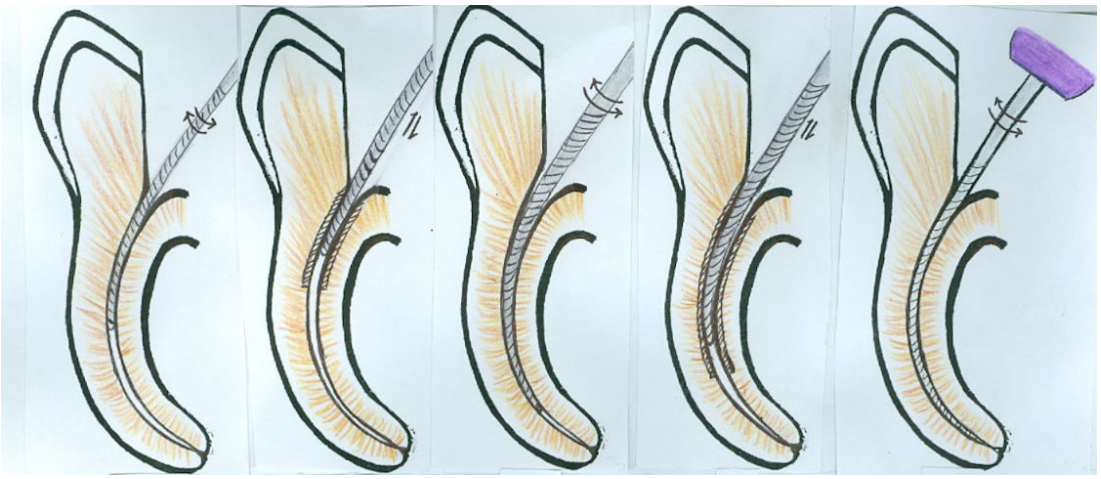

Figure 1. Brush and follow motion for reaching the working length

these days, hand instrumentations are still the teaching methods in dental schools [6] and so many dental students and dentists still use them. An adequate hand instrumentation method can boost the dentist's skills and give him the vision of using rotary instruments and their sequences [1, 5]. Thus improvement of hand instrumentation should not be neglected.

The first techniques of canal preparation were Ingle's standard technique [7] and then step-back technique [8] which focused on root canal preparation in an apico-coronal direction. These pioneer techniques offered the advantage of being easy to learn; however, the first one couldn't achieve a proper cleaning and shaping of the root canal and the second technique carried the risk of working length loss [9], ledge formation, transportation [10], perforation and packing the debris [11].

Then the corono-apical techniques were proposed which improved the results but were hard to learn [12]. The possibility of ledge formation increased due to the primary use of larger size Gates Glidden drills. Also, if any procedural accident happened (such as instrument fracture or ledge formation, *etc.*), its correction was hard and if the correction was not achieved, the left of root canal would remain untouched and that would decrease the prognosis of the treatment [13]. On the other hand, the greater amounts of dentin were removed to access the apical regions which weakened the root [14].

Bolourchi Hybrid Technique (BHT) is a hybrid technique proposed for dental students and dentists who seek an easy-to-learn, safe and fast technique with ideal shaping ability. In this technique the sequence of instruments and hand motions are presented in a way that decrease the possibility of procedural accidents and the instruments that are used in each step have the most efficacy in the proper sequence.

Considering that each technique has its own advantages and disadvantages and none of them has the adequate efficacy in every aspect, it seems reasonable to use a hybrid technique which has the advantages of all other techniques and not their disadvantages. Besides, recent hand instrumentations do not impart today's instruments, and it is essential to update these techniques. The aim of the present study was to compare the BHT with step-back and passive step-back techniques regarding shaping efficacy, maintenance of working length and occurrence of procedural accidents such as apical perforation, ledge, transportation, *etc.*

Materials and Methods

A total of 30 freshly extracted human molars (15 mandibular and 15 maxillary molars) with root canal curvature between 20-70 degrees according to Schneider's method [15] were chosen for this study. All of the root canals of each tooth except the second mesiobuccal canals of maxillary molars were used. Teeth were stored in 5.25% sodium hypochlorite for 24 h and then in normal saline prior to procedure. Teeth were mounted in a single mounting jig using silicone dental impression material (Speedex putty; Coltene, Alstatten, Switzerland).

The tooth were placed in endo training model (VDW GmbH, Munich, Germany). Straight line access were performed and working length was measured using apex locator (Root ZX, J. Morita Corp, Kyoto, Japan). Teeth were randomly divided in 3 groups of 10 (5 mandibular molars and 5 maxillary molars). At first, necessary clinical and radiographic examinations of the tooth were done. Tooth rotations, anatomical variations, calcifications, distance of pulp chamber from occlusal surface (in the radiography images) were considered. The access cavity was prepared in a way that provided straight line access to orifices of

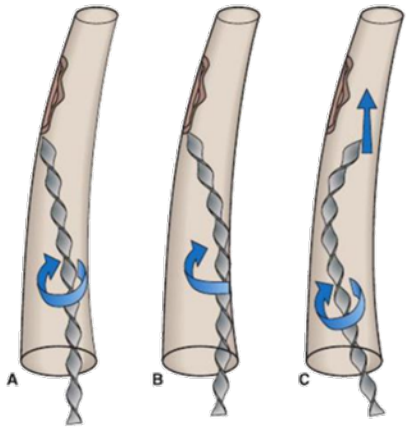

Figure 2. The curve at file's tip makes it a smart file which can pass the barriers in the canal by being rotated or if the portal of exit is placed lateral to the apex

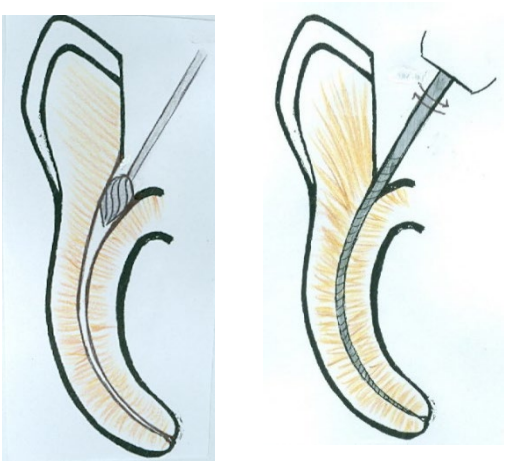

Figure 3. Coronal flaring using size #3 GG then watch winding motions using instrument #15

the canals. Each canal orifice was placed in one angle of access cavity and the operator's instrument was able to be inserted easily while leaning against the access cavity walls. Also unnecessary widening of the base of the access was avoided.

Group 1, Bolourchi Hybrid Technique (BHT)-Technical description

Glide path and apical enlargement: After preparing straight line access, a #8 K-file was pre-curved and then inserted into the canals using a lubricant. If any resistance was felt during the insertion of the instrument, the instrument was pulled up from the resistance point. Then up-and-down motions with low amplitude (about 1-3 mm) was done. With insertion of the instrument using a gentle clock-wise and counter clock-wise rotation, the resistance point was transferred 1-2 mm apical to the point it was felt before. These motions were repeated to reach the working length in a way that each instrument flares the canal by itself. This sequence of motion is called brush-and-follow (Figure 1). This is one of the most important steps of the instrumentation and it is important to avoid applying excess pressure during instrumentation.

If the instrument couldn't penetrate any further after some up-and-down motions in the coronal area, it was pulled out and inserted again with a 30-40 degree curve at the tip. Using exploring motions, with no excess pressure, portal of exit was found. The curve at file's tip makes it a smart file which can pass the barriers in the canal by being rotated or if the portal of exit is placed lateral to the apex (Figure 2), it can find the right path and maintains the patency. This portal of exit must be maintained open during the treatment.

Working length was confirmed using an apex locator and the apical widening was continued until a size #10 K-file was achieved using watch winding and up-and-down motions to create a sufficient glide path. Then the coronal area was widened using #3 GG drill and the dentinal bulges are removed (Figure 3). Using a #3 GG drill causes a straight line access to the apical areas of the canal, enables more tactile sense while using instruments, and helps in removing most of the coronal micro-organisms and contaminations and minimizes working length changes due to removing of coronal bulges and achievement of a more accurate working length.

Coronal pre-flaring with GG after insertion of a #10 K-file, widens the canal enough for size #3 GG and avoids ledge formation in coronal areas. Thus, in large canals size #3 GG can be used after exploring motions with #8 file. At this step, working length is re-confirmed using apex locator or radiographs. Afterwards, a #15 K-file is used with watch winding motions to reach the working length with enough irrigation.

For instruments larger than size #20, the apical area was prepared using balanced force motion (Flexofiles, Flex-R or K-files are recommended for this motion) as follows: The file was inserted and then rotated quarter-turn clockwise (which should not exceed 180 degrees) applying light apical pressure. Then the file was rotated 3/4 turn in a counter-clockwise direction (which should rotate at least 120 degrees or more) with sufficient apical pressure to hold the instrument in the proper working length. Then the file was rotated 1/4 turn clockwise while being pulled out (Figure 4). During the procedure all file tips were cleaned from debris to prevent debris packing and loss of working length due to the outward movement of the file and debris, minimize the risk of ledge formation and transportation and to speed up dentin removal. After some balanced force motions and enough widening of the apical area, a same size H-file was inserted to the

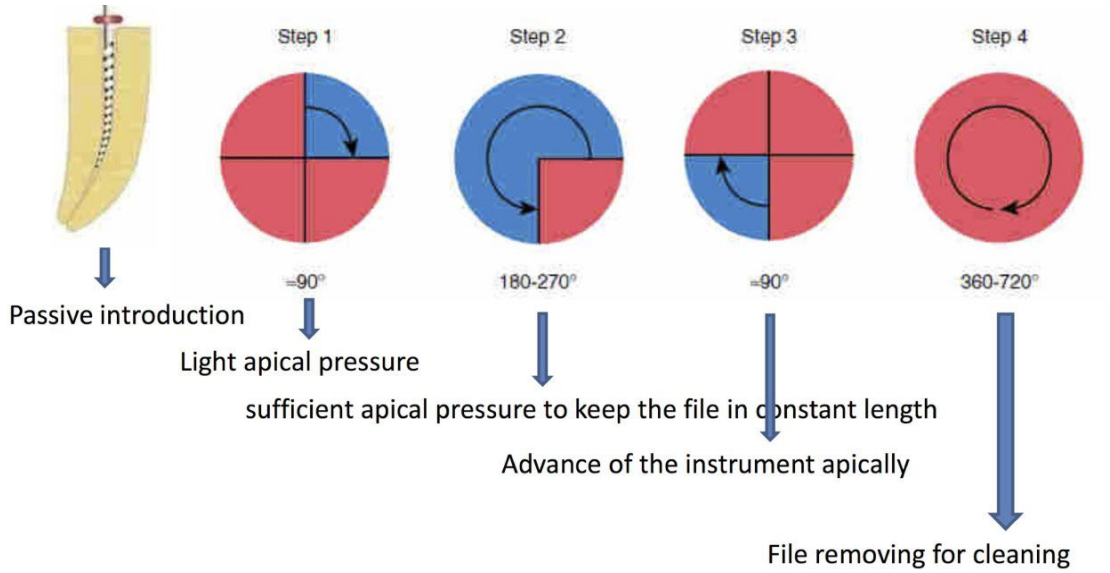

Figure 4. Balanced force motion: the file is rotated ¾ turn in a counter-clockwise direction with sufficient apical pressure. Then the file is rotated ¼ turn clockwise while being pulled out (Schematic illustration from Ingle Endodontics)

canal using up and down motions considering the danger zone and anti-curvature technique proposed by Abou-Rass [16] (Figure 5). This sequence of file motion (some balance force motions using recommended files and then up and down motions using same size H-file) was done until the size #25 instrument can easily reach the working length (Figure 6). H-files are safe instruments and are more flexible and have upward cutting blade. Thus using H-files results in less transportation and ledge formation [17] and cause faster removal of dentin

The crown-down step using Gates Glidden drills: At first, the path of insertion of the canal is checked using a #20 instrument. The GG drill should penetrate the canal in the same direction. The canal was filled with 5.25 % sodium hypochlorite and a #4 GG is inserted to canal orifice without being activated. When it bonded toward the canal walls it was pulled up about 1 mm and then it was activated and with one push was inserted into the canal and stopped when a resistance was felt. Then it was activated again and was pulled out of the canal. Afterwards #3 and 2 GG drills, were used in the same way (Figure 7). Each GG is placed 2 mm more apically than the last GG in the canal. A rubber stop can be used to check the length of GG that inters the canal. It is important to consider that GG penetrates the canal up to the beginning of the canal curvature. Excessive apical pressure or numerous up-and-down motions while using GG was avoided. With this approach about 2/3 of the canal was prepared with sufficient taper and the #2 GG penetrates about 3-4 mm from the apex in straight canals and about the beginning of the curve in curved root canals. After sufficient irrigation, the patency is maintained using a small size instrument and the working length is checked again because of the possible working length changes due to canal straightening after coronal flaring.

Final shaping: The canal preparation continues using a #30 K-file which reaches the working length after some balanced force motions, then the same size H-file was inserted in canal using up-and-down motion (considering the anti-curvature technique). The apical region was widened up to #30 or #35. The size of master apical file (MAF) was chosen considering root width and canal curvature and was not related to the size of initial instrument. It is recommended to choose the MAF between #25 and #45. In order to prepare a funnel shape (apical control zone), the *three* next sequentially larger instruments were inserted into the canal about 0.5 and 1 mm away from the apex with the same motion sequence described before (some balance force motions using recommended files and then up-and-down motions using same size H-file). After final irrigation dry reaming or apical clearance is done. A final confirmation of working length using an apex locator is recommended before obturation.

Final considerations: *1)* Patency should be maintained during all the steps and it is better to be checked between instruments, *2)* Between the different instruments, sufficient irrigation should be done. In order to dissolve remaining pulpal tissues in accessory canals and isthmii, it is recommended to use the standard method for smear layer removal (use of 10 mL of 5.25% NaOCl for 3-5 min followed by 10 mL of 17% EDTA for 1 min) (agitating the NaOCl solution by means of ultrasonic and sonic devices, Endo Activator or at least through the rapid up-

Figure 5. Fingers position for anti-curvature technique

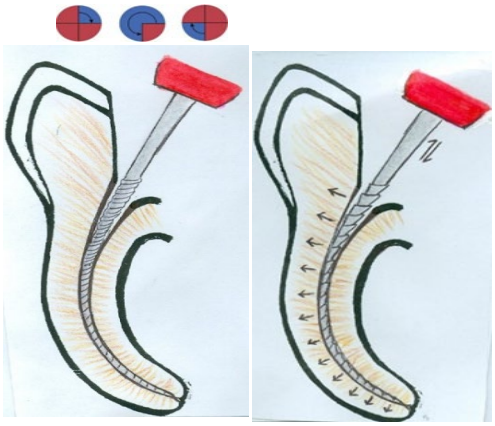

Figure 6. Balance force motions using recommended files and then up and down motions using same size H-file

and-down movements of the master gutta-percha cone promotes the results) [18]. *3)* The canal must be filled with some 5.25% sodium hypochlorite drops during whole procedure. *4)* As a general rule, whenever a file faces difficulty reaching the apical third, the coronal area needs more preparation to eliminate the coronal interferences [19]. This rule should also be considered when coronal penetration of instrument is difficult which necessitates more apical preparation. *5)* Excessive apical pressure in order to reach the working length should be avoided.

Group 2, Step-back

The root canals were prepared by step-back technique [20] using stainless steel K-File and K-Flexofile (Dentsply Maillefer, Ballaigues, Switzerland). The master apical file (MAF) size was determined using the Grossman criterion [2] of three sizes larger than the first file that reached the working length. Preparation continued using a step-back technique in 1-mm increments for three file larger that master apical file (MAF) size. Recapitulation with the MAF at the working length was performed after each step-back size file.

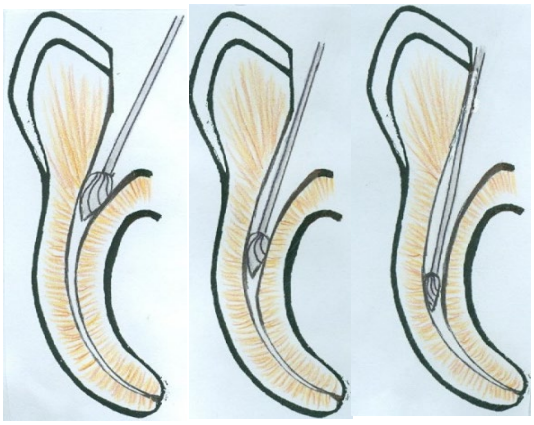

Figure 7. Sequence of using GG drills in crown-down step of the technique

Group 3, Passive step-back

Teeth were prepared according to passive step-back technique introduced by Torabinejad [21] using stainless steel K-File and K-Flexofile (Dentsply Maillefer, Ballaigues, Switzerland) and Gates Glidden drills (Mani, Tochigi, Japan).

Comparison of the groups

Then each tooth in different groups were obturated using lateral condensation technique.

All the procedure was done by trained dental students. Digital Radiographs of each tooth with initial file and master apical cone and obturated teeth were taken using digital periapical radiographs (Owandy Krystal-X Easy, Croissy-Beaubourg, France) during procedure and time of preparation for each tooth was recorded in minutes. Then three endodontists blindly scored each tooth between ranges of 0-100 for these items: difficulty of the case, shaping efficacy, maintenance of working length. They were also asked to report any procedural accidents such as apical perforation, ledge, transportation and *etc.*

Statistical analyses

Normal distribution of samples was evaluated using one sample K-S test. Also hypothesis of equality of variances was evaluated using Levene test. Two-way ANOVA was used to analyze the data. Multiple comparisons were done using Tukey's HSD. The analyses were carried out using SPSS (Version 18.0, SPSS, Chicago, IL, USA). The level of significance was set at 0.05.

Results

According to equality of variances two-way ANOVA analyses showed no significant differences for time of preparation between groups (P=0.166). Difficulty of cases also showed no significant difference (P=0.086). However, shaping efficacy was different in groups (P=0.008). Tukey's test showed that

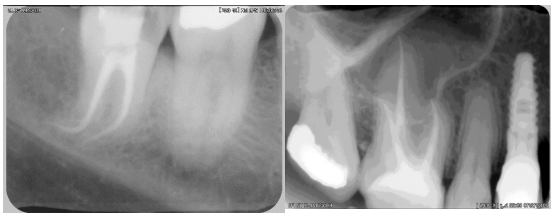

Figure 8. The clinical experiences of the developer (Dr. I Bolourchi) have shown favorable results

BHT group had the highest and step-back group had the lowest score (P=0.006) but passive step-back group did not show significant difference with BHT group (P=0.399) or step-back group (P=0.116).

Results for maintenance of working length were similar to those of shaping efficacy. BHT group was significantly better and step-back group was significantly worse at maintaining the WL but there were no significant differences between passive step-back and BHT and step-back groups.

No interactions between mandibular or maxillary molars and preparation techniques was found for none of the variables. Procedural accidents were only reported in step-back group. Transportation and perforation were reported in 3 of the maxillary teeth and ledge formation and transportation were reported in 2 mandibular teeth (Table 1).

Discussion

The present article described a novel hybrid root canal preparation technique that tries to combine the advantages of previous root canal preparation techniques. Traditionally, manual canal shaping is achieved using ISO-standardized stainless steel instruments with 0.02 tapers. The 16-mm bladed area of the instrument becomes wider by 0.02 mm every millimeter along their length and the instrument design is complemented by a sharp or non-cutting tip. Although instruments are available as reamers or files, most reports recommend the use of the latter. As stated earlier, mechanical instrumentation of the root canal system is an important phase of root canal preparation as it creates the space that allows irrigants and antibacterial medicaments to more effectively eradicate bacteria and eliminate bacterial byproducts [3, 6]. In the literature various terms have been used for this step of the treatment including instrumentation, preparation, enlargement, and shaping [3].

Although Fauchard, as one of the founders of modern dentistry, described instruments for preparation of root canals and cauterization of pulps in his book [22], no systematic description of preparation of the root canal system could be found in the literature at that time. In 1852 Arthur used small files for root canal enlargement [23]. In 1885 Gates Glidden drill and in 1915 K-file were introduced [24]. However, standardization of instruments with proposed ISO specifications for endodontic instruments were not published before 1974 [25]. In 1961, Ingle [7] described the first formal root canal preparation technique, known as the 'standardized technique' in which each instrument was inserted to the working length resulting in a canal shape that matched the taper and size of the final instrument. This technique was designed for single-cone filling techniques.

Schilder [26] described five design objectives for preparation of the root canal: *i.* Continuously tapering funnel from the apex to the access cavity, *ii.* Cross-sectional diameter should be narrower at every point apically, *iii.* The root canal preparation should flow with the shape of the original canal, *iv*. The apical foramen should remain in its original position, *v*. The apical opening should be kept as small as practical. Moreover four biologic objectives was added to the list including: confinement of instrumentation to the root canal limits, no forcing of necrotic debris beyond the foramen, removal of all tissue from the root canal space and creation of sufficient space for intra-canal medicaments [26, 27].

Table 1. Mean (SD) of case difficulty, shaping efficacy, maintenance of working length and time of preparation

	Technique	Difficulty	Time of preparation (min)	Shaping efficacy	Working length maintenance
Maxillary teeth	**Step back**	67.66 (20.15)	38.40 (8.234)	75.333 (5.700)	78.000 (6.055)
	BHT	80.66 (22.00)	31.60 (7.266)	87.666 (5.082)	89.333 (4.816)
	Passive step back	83.66 (9.38)	39.20 (12.795)	80.333 (7.207)	84.000 (6.411)
Mandibular teeth	**Step back**	55.00 (13.17)	30.80 (6.419)	75.866 (9.242)	77.333 (11.093)
	BHT	71.00 (10.24)	33.20 (5.805)	85.000 (7.817)	89.666 (6.055)
	Passive step back	67.33 (15.79)	40 (7.874)	84.000 (6.519)	85.666 (8.866)
Total	**Step back**	61.333 (17.380	34.60 (8.030)	75.600 (7.244)	77.666 (8.432)
	BHT	75.833 (16.96)	32.40 (6.257)	86.333 (6.373)	89.500 (5.155)
	Passive step back	75.500 (14.97)	39.60 (10.024)	82.166 (6.760)	84.833 (7.347)
	Total	70.888 (17.31)	35.53 (8.529)	81.366 (7.954)	84.000 (8.459)

This is an educational method which can help dental students to learn different file motions and learn how to use GG burs. Also using a special file for each motion can help students to choose their own strategy to manipulate different canals.

Considering the basic fundamentals of root canal preparation presented BHT offers many advantages which will be discussed in detail. The coronal area of the canal is widened as the size of each instrument. Since the diameter of the apex is usually equal to the size of a #15 instrument [28], the primary insertion of a #15 instrument to the canal, compacts the pulpal tissue in the apical area and makes patency hard to achieve which leads to packing debris, working length loss and transportation [19]. By elementary insertion of a #8 or 10 K-file in BHT, this problem is overcome. Primary use of size #8 instrument can give the operator enough information about canal anatomy such as obliterated canals, excess canals, apical curves, *etc,* which helps the operator act more cautious. Pulpal tissue is removed in several steps, and using a lubricant can prevent from gathering and developing into an apical plug. Using balanced force in BHT sequence, increases cleaning effectiveness of this technique [29], decreases debris extrusion [30] and loss of working length [30, 31]. Moreover, less transportation is expected due to centric placement of the files in balanced force motion [8, 12, 17]. The risk of strip perforation is lowered due to use of GG burs in crown-down manner and balanced force motion and application of anti-curvature technique [32].

In this novel sequence, since the tip of the file is the only active part in removing dentin, danger zone wouldn't be trespassed and possibility of strip perforation is decreased [31]. Moreover, preparing the canal up to size #25, leads to the penetration of GG in proper length (about 3-4 mm from the apex in straight canals and up to the beginning of the curve in curved root canals). Also the possibility of strip transportation [32], ledge, perforation and GG fracture decreases due to avoiding unnecessary circumferential and up-and-down motions.

The presence of sodium hypochlorite absorbs the heat produced by using GG drills which also increases its tissue dissolution ability [33, 34]. Also debris floats in the hypochlorite so they're removed easily by irrigation. The clinical experiences of the developer (Dr. I Bolourchi) have shown favorable results (Figure 8) and our studies in Shahid Beheshti University of Medical Sciences, Dental School, on comparing BHT to passive step-back technique, has resulted in less transportation in canals prepared with this technique. Also this technique seems to be faster than passive step-back technique. Although time of preparation showed no statistically significant differences between groups, considering the mean of the groups on this item (BHT: 32.4 min, step-back: 34.6 min and passive step-back: 39.6 min) these differences can be valuable clinically.

Conclusion

Accurate use of this technique has considerably better results than other hand instrumentation techniques. Further studies should be done on this technique and it should be compared to other techniques, considering different aspects.

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Conflict of Interest: 'None declared'.

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