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Removal of Endodontic Fiber Posts using Dynamic Guidance: A Novel Approach

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by

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Abstract

<u>Introduction:</u> Retreatment of root canals often involves removal of obstructions. Commonplace are fiber posts that have been placed that require drilling of the post to gain access to the root canal system. Guided endodontic procedures, and more specifically Dynamic Guidance is an emerging field in dentistry.

<u>Objective:</u> To determine whether dynamic navigation instrumentation is more accurate and more efficient at bonded fiber post removal than free-hand removal.

<u>Materials and Methods:</u> Thirty maxillary incisors were treated endodontically using the ProTaper Gold system and obturated with warm vertical compaction. Post space was prepared and size 2 fiber posts were bonded into the canals. Teeth were mounted in acrylic arch forms. Preoperative CBCT scans were taken and imported into the X-Guide system. Using the X-Guide software, drill trajectories and depths were planned for the removal of the posts for all 30 teeth. The teeth were randomly divided into two groups of 15. In group 1, the posts were removed using the X-Guide system by a second year endodontic resident. In group 2, the posts were removed "freehand" by an experienced endodontist (17+ years of experience). The time to remove the posts was recorded for both groups. Repeated measures analysis of variance models (ANOVA) were run for each outcome. The times to perform the procedure were compared for each group, a repeated measures ANOVA was run to compare groups. Post-operative CBCT images were taken and all teeth were analyzed for accuracy of the depth and trajectory of the performed drill path and compared to the depth and trajectory planned by the X-Guide software. Repeated measures analysis of variance models (ANOVA) were run for each outcome.

<u>Results:</u> The times comparing Group 1 (X-Guide) with Group 2 (Freehand) are depicted in Tables 1a and 1b. The mean time for post removal for Group 1 was 38.6 seconds (± 16.12) which was significantly lower (p-value 0.0006) than for Group 2, which was 524 seconds (± 430.56). The average angular deviation for Group 1 and Group 2 was 1.13 degrees (±0.47) and 3.16 degrees (±1.71) respectively, and the difference was significant (p-value 0.0004) . The average non-depth deviation at the access site on the occlusal surface was 0.365 mm (±0.14mm) for Group 1 and 0.621 mm (±0.27) for Group 2, the difference was significant (p-value 0.004). The average apical non-depth deviation at the apical extent of the drill path for Group 1 was 0.298 mm (±0.14mm) and for Group 2 was 0.381mm (±0.32), the difference was not significant. The average apical depth deviation at the apical extent of the drill trajectory was -0.1295mm (±1.11mm) for Group 1 and 1.026 mm (±1.29) for Group 2, the difference was significant (p-value 0.004

<u>Conclusions:</u> Using a Dynamic Guidance system to remove bonded endodontic fiber posts is both quicker and more accurate than free-hand removal.

Introduction

The goal of endodontic treatment is to prevent or heal apical periodontitis(1). Endodontic treatment enjoys a high degree of success(2), however, apical periodontitis may persist or reoccur after treatment. The management of post treatment apical periodontitis includes either orthograde retreatment or retrograde surgical treatment. Orthograde retreatment is considered one of the more challenging treatments in dentistry(3). In order to perform endodontic retreatment, it necessitates the removal of any previous root canal filling materials to gain access to the apex. If an endodontic post is present, its removal is necessary. The removal of an endodontic post is challenging and can affect the clinician's treatment decisions on whether to retreat the tooth by an orthograde approach or proceed to a surgical approach(4). The decision to attempt to remove an endodontic post is further influenced by the operator's experience and skill(5).

Numerous methods for endodontic post removal have been documented; most of these methods involve the removal of the surrounding tooth/core structure to expose the coronal aspect of the post. They vary in their ultimate means of post retrieval, some include the application of ultrasonic instruments to the post to vibrate it free and disrupt the post-cement-dentinal interface to facilitate removal, or preparation of the exposed coronal end of the post and the use of various post removal "kits", which are essentially designed to apply sustained traction to the post in a relatively controlled manner(6). These methods of post removal are generally reserved for metal posts.

Metal-free fiber posts are considered to be advantageous for improving the performance of restorations (7, 8) because their physical properties are similar to those of dentin, and they have improved esthetic properties (9). Several dentin bonding techniques have also been developed to ensure maximal adhesion of post systems (10). The presence of a fiber post–supported restoration may further influence the difficulty of reaching the root canal system and apex (11), largely due to the bonding of the fiber post to the root canal space. Although the intact retrieval of fiber posts is possible(12), due to the physical properties of fiber posts and the strength of the dentin bonding techniques used to secure these posts, the techniques for fiber post removal generally involve drilling or boring through the post as opposed to intact retrieval of the post(11, 13-15). Drilling or boring out a fiber post can easily lead to substantial loss of surrounding dentine and may result in root perforation or severe weakening of the tooth, predisposing it to root fracture(16). In a recent case report by Schwindling, the utilization of a 3D printed stent fabricated using a virtual plan derived from a preoperative CBCT scan to remove a fiber post was demonstrated with a successful result.

Recently, new possibilities for endodontic procedures have been described. Zehnder et al. introduced the concept of "guided endodontics" to facilitate the preparation of the access cavity for teeth with pulp-canal calcification (17). In this application, a pre-operative CBCT is used to virtually plan the tooth for preparation. Tooth-supported splints are three-dimensionally (3D) printed and serve as guides during preparation. The use of these 3-D printed static guides have been introduced in endodontics and used for “minimally invasive” guided access cavities(18-21), access of calcified teeth(17), and in root-end apical surgery to aid in osteotomy preparation(22). These studies have all employed the use of CBCT imaging, intraoral scanning, and 3D printers to ultimately produce a “static guide” or stent to be used in the procedure. Recently, in dental implant surgery, dynamic computer-assisted methods have been used. In these cases, an intraoperative real-time tracking device is used to monitor whether the previous treatment plan is being correctly followed(23). This “dynamic guidance” eliminates the need for fabrication of a 3-D stent. Zubizarreta-Macho recently used dynamic guidance to endodontically access teeth and found the technique to be highly accurate(24).

X-Guide (X-Nav Technologies, Lansdale, PA) is a dynamic 3D navigation system designed for implant placement. Through the use of stereoscopic cameras and fiducial markers (both on the patient and the handpiece), the system enables the operator to follow a virtually planned trajectory in real time. Endodontic applications of this technology are emerging.

To this date, no published study has investigated the feasibility of utilizing a dynamic guidance system to remove endodontic fiber posts from teeth. This in vitro study aims to investigate the efficiency and accuracy of utilizing dynamic guidance to remove resin bonded fiber posts from endodontically treated teeth. The study will also compare the utilization of this technique as performed by an endodontic resident with that of an experienced endodontist (17+ years) utilizing a “freehand” technique. To measure the efficiency, the time to remove the post, from initial access until the post is successfully drilled through, will be measured using a dynamic guidance and a manual “freehand” technique, the times for each technique will be compared. To measure the accuracy, the positional deviations both coronally and apically of the performed drill path shall be compared to the virtual plan of the guided access. The angular deviation of the performed drill path in relation to the virtual plan shall be evaluated as an additional parameter to measure the accuracy of the technique.

Materials and Methods

Thirty previously extracted single rooted maxillary incisors were selected for the study. The teeth selected were of similar length and size.

Specimen Preparation

The teeth were accessed using a 556 high speed fissure bur using water coolant. After access, the working length of the teeth was determined by insertion of a stainless steel size 10 K-file (Dentsply Sirona Endodontics, Ballaigues, Switzerland) until its tip appeared at the apical foramen under optical inspection (Global Surgical Corporation, St Louis, MO). The teeth were cleaned and shaped using the ProTaper Gold rotary file system (Dentsply Sirona Endodontics, Ballaigues, Switzerland) in a S1-S2-F1-F2-F3 sequence. The teeth were irrigated with 5.25% sodium hypochlorite throughout the cleaning and shaping procedure. All teeth were prepared to an F3 rotary file apically (ISO size 30 with a taper of 0.09). After cleaning and shaping was completed, all teeth were subjected to a final irrigation protocol of 5 ml 5.25% sodium hypochlorite, sonically activated for 30 seconds (EndoActivator, Dentsply Sirona Endodontics, Ballaigues, Switzerland), followed by irrigation with 1 ml 17% EDTA sonically activated for 1 minute, followed by 5 ml 5.25% sodium hypochlorite sonically activated for 30 seconds. The canals were then dried with paper points. Canals were fitted to working length with corresponding F3 gutta percha points (Dentsply Sirona Endodontics, Ballaigues, Switzerland), this was verified with a periapical radiograph (XDR Radiology, Los Angeles, CA). The teeth were obturated using gutta percha and AH Plus sealer (Dentsply Sirona Endodontics, Ballaigues, Switzerland) via warm vertical compaction. The canals were downpacked using System B (Kavo Kerr, Brea, CA) to 5mm short of working length. Post space was prepared in the canals using a size 2 (red) DT Light post drill (Bisco Dental, Schaumburg, Il), and the canals were cleaned with 70% isopropyl alcohol to remove any residual filling material in the prepared post space. The prepared post spaces were inspected under microscopic magnification to ensure they were free of debris. Size #2(red) DT light (Bisco Dental, Schaumburg, Il) fiber posts were bonded into the canals using Rely X Unicem 2 self adhesive cement (3M, St Paul, MN). After post cementation, periapical radiographs were taken to insure proper post placement without any substantial voids between the post/luting agent and the apical gutta percha. The pulp chamber and access cavities were then restored with Grandio Core dual cure restorative material (Voco dental, Cruxhaven, Germany). At this point, the teeth were mounted into anatomic maxillary arch forms with Jet Acrylic (Patterson Dental, St Paul, MN).

Pre-Operative CBCT scans

Each maxillary arch was fitted with an X Clip (X-Nav Technologies, Lansdale, PA), which is a custom fit clip with embedded fiducials which allow the dynamic guidance system to orient itself. A full arch CBCT scan was taken of each arch with X-Clip in place using a Planmeca ProMax 3D Max (Planmeca, Helsinki, Finland) CBCT scanner.

Surgical Case Planning using X-Guide

The intraoral scans were imported into the Dynamic Guidance system software X-Guide (X-Nav Technologies, Lansdale, PA) for case planning. Each tooth was surgically planned using the implant planning placement software. Normally the X-Guide software is an implant planning software, by customizing the dimensions of the “planned implant” to having an apical diameter of 0.5 mm and a coronal diameter of 0.5mm, it was utilizable in an endodontic application. The trajectory of the “planned implant” was directly through the center of the fiber post to a depth 0.5 mm beyond the apical extent of the post. The length of the “planned implant” was set from the access point on the occlusal surface to 0.5 mm beyond the apical extent of the post.

Post Removal Procedure

The thirty teeth were randomly assigned into 2 groups. In Group 1 (15 teeth), the dynamic guidance system X-Guide (X-Nav Technologies, Lansdale, PA) was utilized to drill through the posts. This procedure was performed by a second year endodontic resident, using a slow speed handpiece (Forza, Brasseler USA, Savannah, GA) and a DT post removal bur (Bisco, Schaumburg, Il) calibrated to the X-Guide software under dynamic guidance. The operator relied solely on the dynamic guidance system for navigation (Figure 2). The time to complete each tooth was recorded. In Group 2 (15 teeth), the posts were removed "freehand" by an experienced endodontist (17+ years of experience). In this group, the operator reviewed all pertinent scans and the equivalent digital surgical plan as in the guided cases prior to attempting to remove the posts. The method in which the posts were removed was solely up to the experienced endodontist's discretion. The posts were removed using carbide burs, ultrasonic tips, and post removal drills with the aid of a dental operating microscope (Global). Periapical radiographs were taken as needed to aid in the "freehand" procedure. The time to complete each tooth was recorded.

Post Operative CBCT scans

Post-operative full arch CBCT scans were taken of all teeth treated with the X-Clips in place. The post-operative CBCT scans were imported into the X-Guide software and a post-operative surgical plan was made by calculating a human-estimated straight-line drill trajectory by placing an implant of identical dimensions to the preoperative surgical plan through the actual access opening. The preoperative and post-operative surgical "plans" were superimposed, and the planned procedures were compared with the performed procedures for each tooth (Figure 3, 4).

Data Collection and Statistical Analysis

Embedded software within the X-Guide system was used to automatically calculate the deviation between planned and performed drill path preparations. The "non-depth" deviation was classified as a deviation in either a bucco-lingual or mesio-distal direction of the performed trajectory compared to the planned trajectory. This was calculated for all teeth (in mm) both at the occlusal surface and at the apical extent of the planned trajectory. The "depth" deviation was classified as the deviation in a coronal-apical direction from the apical extent of the performed trajectory compared to the apical extent of the planned trajectory. This was calculated for all teeth (in mm). The "angular deviation" was classified as the deviation of the performed drill path with the planned path (calculated as an angle). These measurement parameters are illustrated in Figure 1. Repeated measures analysis of variance models (ANOVA) were run for each outcome. The times to perform the procedure were compared for each group, a repeated measures ANOVA was run to compare groups.

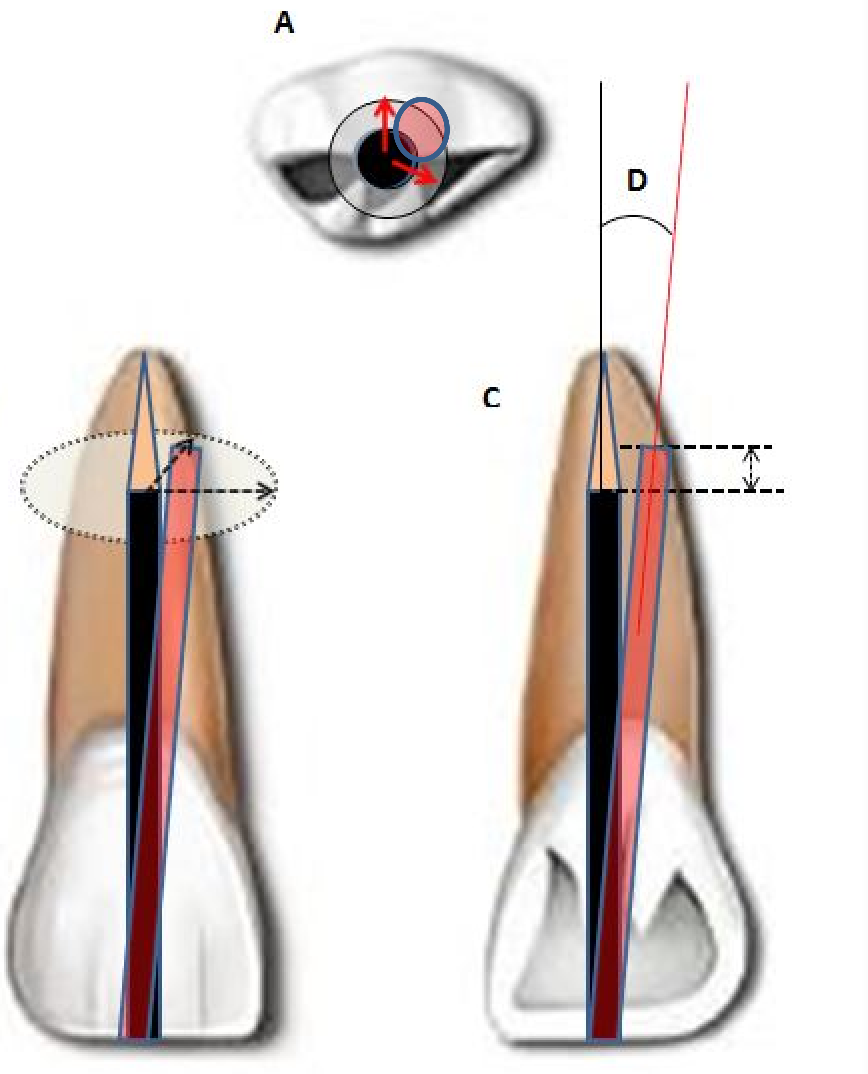

Figure 1: Graphical depiction of measurements taken. A. “Occlusal Non-depth deviation” is defined as the deviation (in any direction ie. mesial-distal-buccal-lingual) of the actual access point on the occlusal surface from the planned access point. The solid black circle represents planned access entry point, while the gray zone surrounding it represents area of potential deviation. B. “Apical Non-depth deviation” is defined as the deviation (in any direction other than apico-coronally) of the actual drill trajectory from the planned drill trajectory of the “cutting end” of the drill ; the black line represents the planned trajectory, the red line represents hypothetical performed trajectory, while ellipsoid represents potential zone of deviation in horizontal plane. C. “Apical Depth Deviation” is defined as the depth deviation (ie. apico-coronal deviation) of the cutting end of the drill in relation to the planned versus actual trajectory. The black line represents the planned drill trajectory while the red line represents hypothetical performed trajectory. D: “Angular Deviation” would be the measurement of the angle formed between the planned trajectory (black line in C) and the performed trajectory (red line in C)

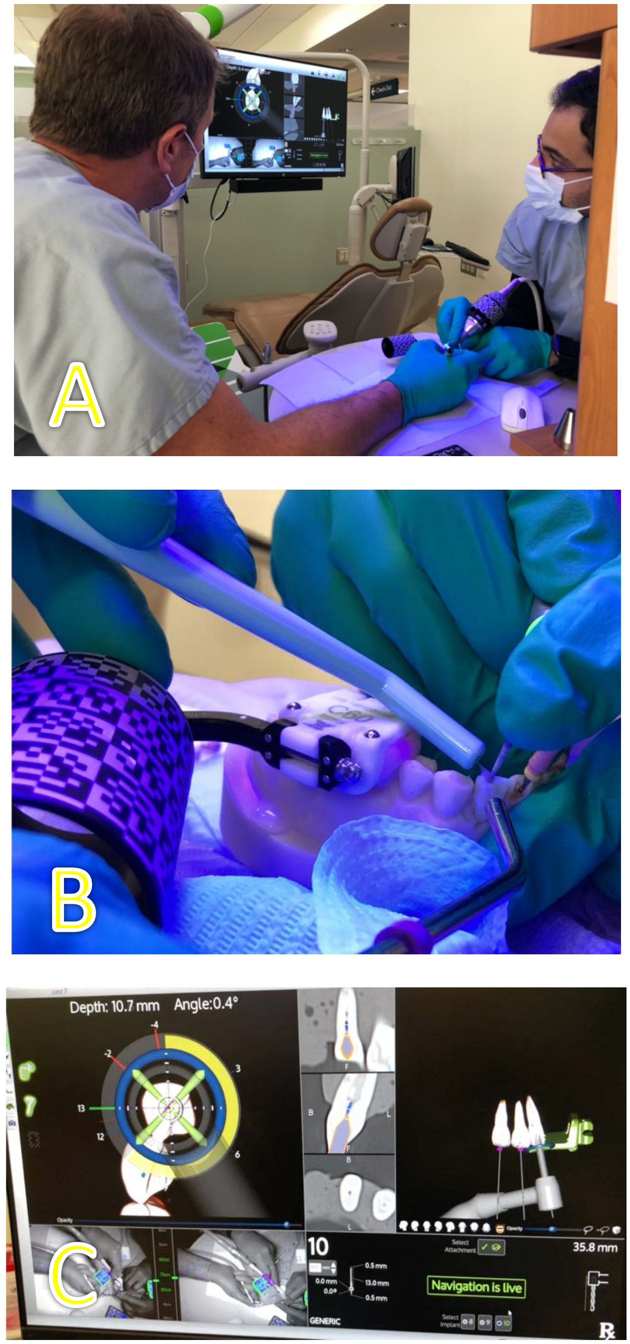

Figure 2: A. Overview of CBCT guided procedure, please note, clinician and assistant are focused on the monitor. **B.** View of procedure at level of dentition, X-Clip in place to allow for proper orientation. **C.** Screenshot of monitor while guided surgical procedure is “live”. Top left quadrant of screen enables operator to visualize position of the head of the handpiece as well as providing a graphical depiction of the depth of the bur as it follows the planned trajectory. Upper right quadrant of the screen provides visualization of the handpiece and bur in relation to CBCT image in sagittal, coronal and axial planes, as well as an overall view of the procedure

Results

Post Removal Times (Efficiency)

The times comparing Group 1 (X-Guide) with Group 2 (Freehand) are depicted in Tables 1a and 1b. The mean time for post removal for Group 1 was 38.6 seconds (± 16.12) which was significantly lower (p-value =0.0006) than for Group 2, which was 524 seconds (± 430.56).

Group 1	**Tooth**	**Time (seconds)**	**Group 2**	**Tooth**	**Time(seconds)**
	1	60		16	360
	2	72		17	240
	3	24		18	420
	4	32		19	18
	5	42		20	480
	6	29		21	1500
	7	24		22	120
	8	32		23	300
	9	54		24	300
	10	64		25	180
	11	32		26	480
	12	37		27	1200
	13	29		28	420
	14	25		29	420
	15	23		30	1260

Table 1a: Table depicting times (seconds) for post removal for Group 1 (X-Nav guided) and for Group 2 (Freehand).

	N	Mean	Median	Std Dev	Minimum	Maximum
Group 1	15	38.60	32.00	16.12	23.00	72.00
Group 2	15	524.00	420.00	430.56	120.00	1500.00

Table 1b: A repeated measures ANOVA was also run to compare groups 1 and 2. There was a significant difference between the two groups (p-value=0.0006).

Performed Drill Path Trajectory Deviation from Pretreatment Planned Trajectory

The results comparing the angular deviation, occlusal non-depth deviation, apical non-depth deviation, and apical depth deviation for Group 1 (X-Guide) and Group 2 (Freehand) in relation to the planned/ideal drill path trajectory are depicted in Tables 2a and 2b. A pictorial representation of the various measurements is depicted in Figure 1.

Group 1

The average angular deviation of the performed drill path for Group 1 in relation to the planned trajectory was 1.13 degrees (±0.47). The average occlusal non-depth deviation (deviation in any direction other than apico-coronally) at the access site on the occlusal surface was 0.365 mm (±0.14mm). The average apical non-depth deviation (deviation in any direction other than apico-coronally) at the apical extent (cutting end) of the drill path was 0.298 mm (±0.14mm). The average apical depth deviation (apico-coronal deviation) at the apical extent of the drill trajectory was -0.1295mm (±1.11mm).

Group 2

The average angular deviation of the performed drill path for Group 2 in relation to the planned trajectory was 3.16 degrees (±1.71). The average occlusal non-depth deviation (deviation in any direction other than apico-coronally) at the access site on the occlusal surface was 0.621 mm (±0.0.27mm). The average apical non-depth deviation (deviation in any direction other than apico-coronally) at the apical extent of the drill path was 0.381 mm (±0.32mm). The average apical depth deviation (apico-coronal deviation) at the apical extent of the drill trajectory was 1.026 mm (±1.29mm).

	Tooth	Angular Deviation (degrees)	Occlusal Non-depth Deviation(mm)	Apical Non-depth Deviation(mm)	Apical Depth Deviation (mm)
Group 1	1	1.9427	0.4966	0.3107	1.05846
	2	1.2664	0.3971	0.2793	-0.9975
	3	1.3205	0.2311	0.0981	0.38053
	4	0.7514	0.6405	0.5558	-3.6618
	5	1.4901	0.4242	0.3751	-0.2178
	6	0.432	0.4559	0.4952	-0.6756
	7	0.4877	0.3471	0.3216	0.0424
	8	1.38718	0.1604	0.2925	-0.1056
	9	1.0596	0.5034	0.3831	0.34512
	10	0.5439	0.3054	0.28	-0.068
	11	0.6078	0.2347	0.0505	0.05564
	12	1.5573	0.4461	0.0563	0.50838
	13	1.4286	0.2272	0.3402	0.27274
	14	1.1374	0.1993	0.3298	0.78014
	15	1.5748	0.4057	0.3024	0.33929
Group 2	16	3.1879	0.5659	0.3486	-1.2707
	17	3.5925	0.7161	0.2464	-0.426
	18	3.2099	0.5802	0.3374	1.08206
	19	2.1409	0.7877	0.2489	0.12437
	20	7.3748	0.8765	1.3745	2.82559
	21	3.291	0.674	0.5461	2.06732
	22	3.7613	0.9032	0.2138	1.31062
	23	3.7975	0.8259	0.2067	1.71296
	24	3.372	0.8375	0.2958	0.40112
	25	1.1092	0.2044	0.1128	2.13701
	26	1.5239	0.1221	0.2231	0.33954
	27	0.8524	0.1085	0.3105	1.18905
	28	5.3639	0.7644	0.7406	3.585
	29	3.6598	0.8019	0.2042	0.25656
	30	1.2026	0.5473	0.3024	0.06202

Table 2a: Chart depicting the analysis of the results of Group 1 (X-Guide) and Group 2 (Freehand). This chart compares the performed drill trajectories of the two groups in relation to the planned/ideal trajectories.

	Label	N	Mean	Median	Std Dev	Minimum	Maximum
Group 1	Angular Deviation (deg)	15	1.1315	1.2664	0.4658	0.4320	1.9427
	Occlusal non-depth deviation (mm)	15	0.3650	0.3971	0.1364	0.1604	0.6405
	Apical non-depth deviation (mm)	15	0.2981	0.3107	0.1420	0.0505	0.5558
	Apical depth deviation (mm)	15	-0.1295	0.0564	1.1057	-3.6618	1.0585
Group 2	Angular Deviation (deg)	15	3.1626	3.2910	1.7107	0.8524	7.3748
	Occlusal non-depth deviation (mm)	15	0.6210	0.7161	0.2702	0.1085	0.9032
	Apical non-depth deviation (mm)	15	0.3808	0.2958	0.3148	0.1128	1.3745
	Apical depth deviation (mm)	15	1.0258	1.0821	1.2890	-1.2707	3.5850

Table 2b: Summarization of data from Table 2a for Groups 1 and 2

Comparison of Group 1 to Group 2

Repeated measures analysis of variance models (ANOVA) were run for each outcome. Two of the outcomes had to be log-transformed for normality (angular deviation (deg) and apical non-depth deviation (mm). All values are presented on the non-transformed scale. The results of the comparison are shown in Table 3. The angular deviation of 1.13 degrees for Group 1 was significantly less than the angular deviation of 3.16 degrees for Group 2 (p-value 0.0004). The occlusal non-depth deviation of 0.365 mm for Group 1 was significantly less than the 0.621 mm deviation for Group 2 (p-value 0.004). The apical non-depth deviation of 0.2981 mm for Group 1 was less than the deviation of 0.38 mm for Group 2, but the difference was not significant. The apical depth deviation of -0.13mm for Group 1 was significantly less than the 1.02 mm deviation for Group 2(p-value 0.004).

	p-value
Angular Deviation (deg)	**0.0004**
Occlusal non-depth deviation (mm)	**0.0040**
Apical non-depth deviation (mm)	**0.3682**
Apical depth deviation (mm)	**0.0040**

Table 3: Repeated measures analysis of variance models (ANOVA) were run for each outcome. Two of the outcomes had to be log-transformed for normality (angular deviation (deg) and apical non-depth deviation (mm). All values are presented on the non-transformed scale. The p-values are shown above. All were significant except for apical non-depth deviation (mm).

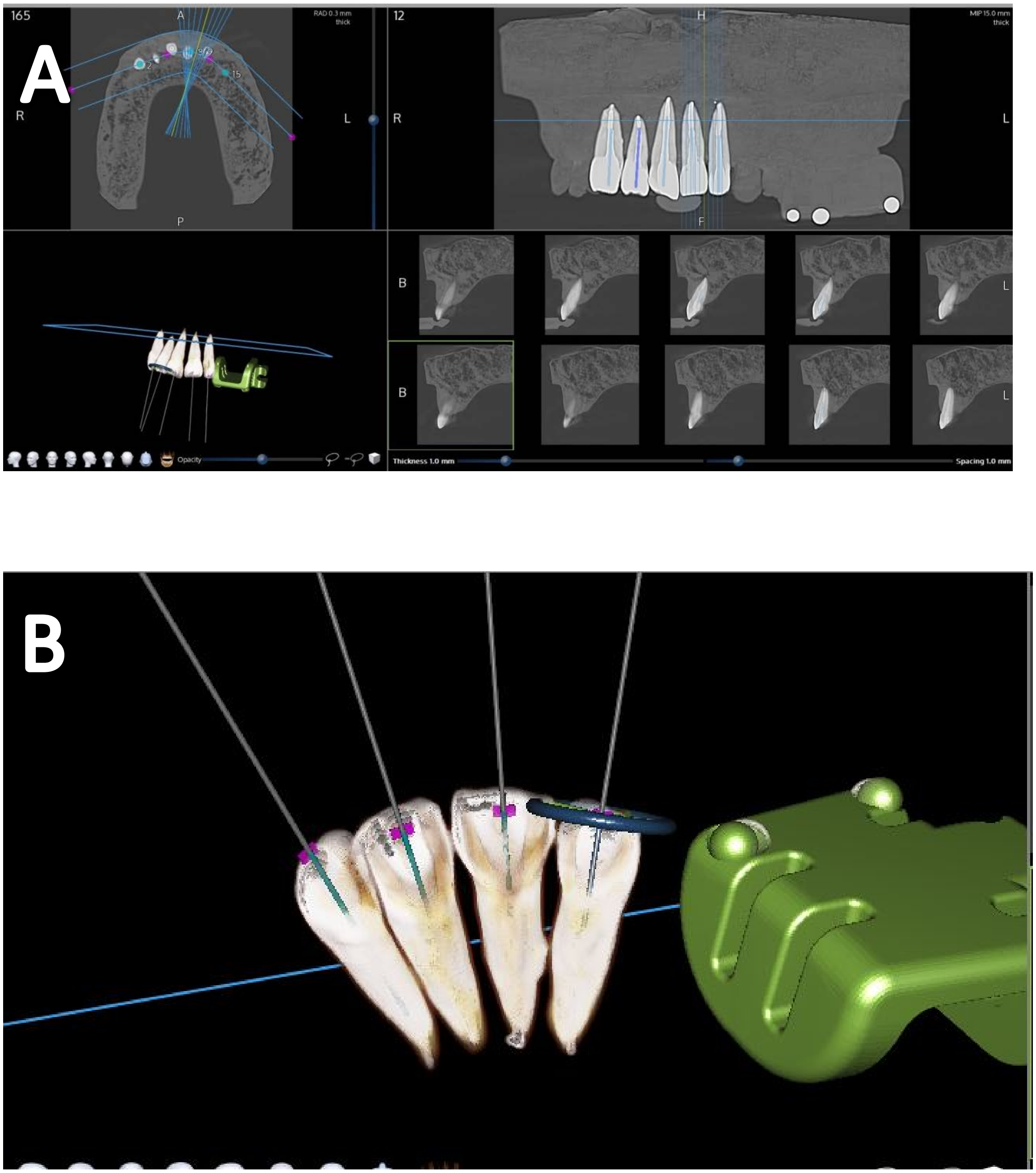

Figure 3: A. Overall view of planned surgery using X-Guide software **B.** Expanded view of planned surgical trajectories

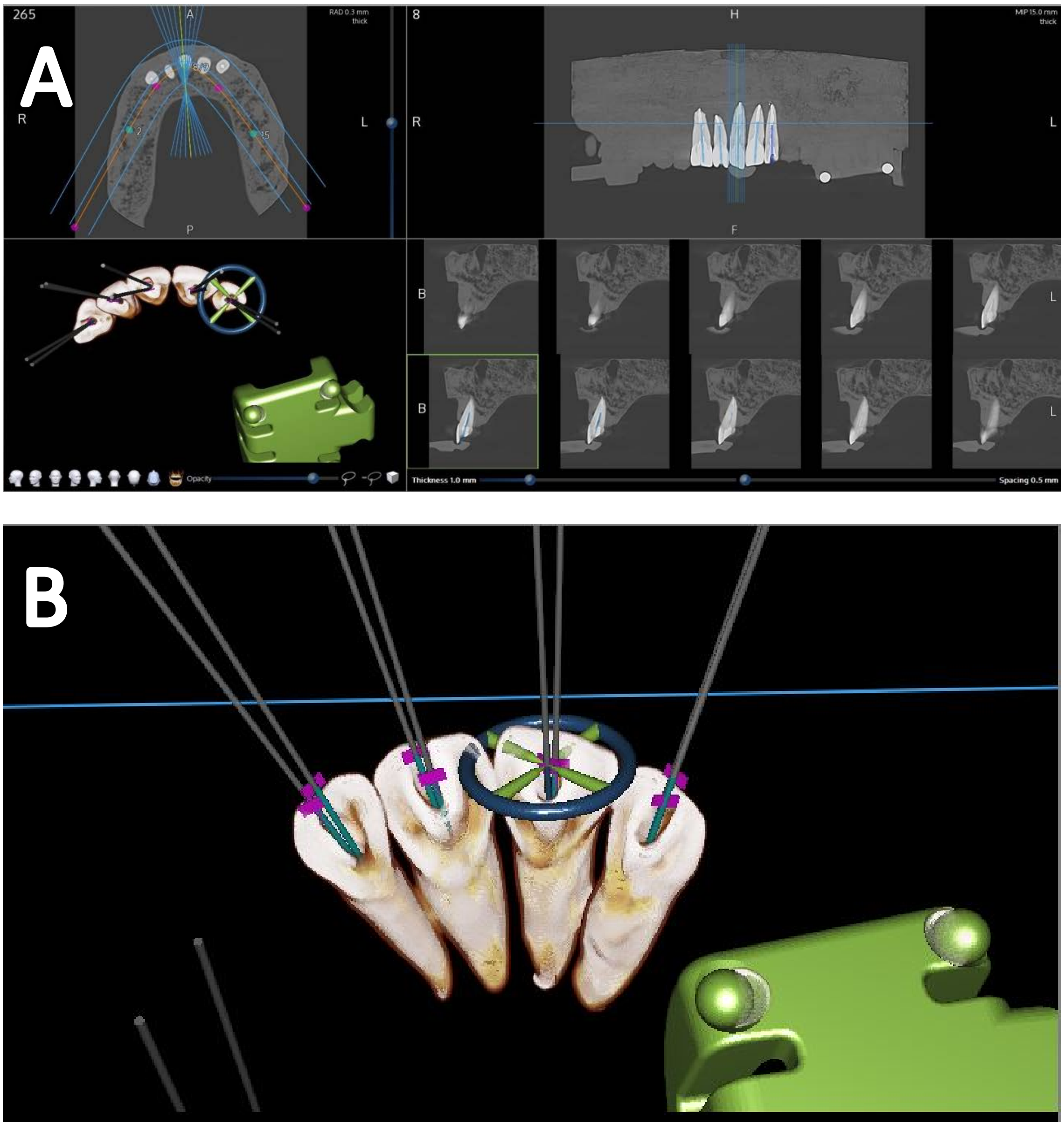

Figure 4: A. Overall view of X guide software with post treatment CBCT image superimposed on presurgical CBCT image/plan. **B.** Expanded view of “actual” trajectories superimposed on image of “planned” trajectories. It is from these superimposed images that the parameters of this study were derived (Occlusal non-depth deviation, apical non-depth deviation, apical depth deviation and angular deviation)

Discussion

In some cases, fiber posts must be removed to regain access to root canal spaces when endodontic treatment has failed because of periapical pathology, or when the existing post itself has fractured. This study investigated a novel approach to fiber post removal. In comparing the dynamically guided technique to a freehand manual technique, the study not only compared the accuracy of the technique itself, but compared it to the methodology commonly used by an experienced, skilled endodontist. Furthermore, by having an endodontic resident utilize the dynamically guided technique, the study sought to illustrate that guided endodontic post removal is both accurate and efficient and essentially simplifies a complicated procedure that an inexperienced operator would normally deem challenging.

The results of this study show that utilizing a CBCT guided dynamic guided system is an efficient method to remove a resin bonded endodontic fiber post. The utilization of a dynamic guidance system to remove the fiber post proved to be significantly faster than a freehand technique performed by an experienced operator. Scotti et al showed that an experienced dentist takes significantly less time to remove a fiber post(11) than an inexperienced dentist. This further emphasizes the efficiency of dynamic guidance, not only is the technique itself significantly faster, but it minimizes the disparity between experience and inexperience. That being said, there is a learning curve to using dynamic guidance. According to the manufacturer (X-Nav Technologies), the operator should practice on a minimum of 25 teeth to gain familiarity with the system. Prior to engaging in the study, the resident became quite proficient at utilizing the dynamic guidance system. So in this study, "experienced" is a relative term, the resident, one could argue was experienced using dynamic guidance(25), while the endodontist with 17 years of clinical experience was experienced and proficient at manually removing posts. Nonetheless, it is an interesting contrast and comparison.

In comparing the treatment times between the dynamic guidance group and the manual freehand group it should be noted that this was a direct comparison of essentially the treatment or "chairside" times only. Performing any CBCT guided procedure necessitates procurement of a preoperative CBCT and subsequent surgical planning on the computer guidance software, the time taken for CBCT scan acquisition and presurgical planning was not taken into account for this study. However, the current joint position statement put forth by the American Association of Endodontists and the American Academy of Oral and Maxillofacial Radiologists on the Use on Cone Beam Computed Tomography in Endodontics recommends that "Limited FOV CBCT should be the imaging modality of choice when evaluating the non-healing of previous endodontic treatment to help determine the need for further treatment, such as non-surgical, surgical or extraction" and also "Limited FOV CBCT should be the imaging modality of choice for non-surgical re-treatment to assess endodontic treatment complications, such as overextended root canal obturation material, separated endodontic instruments, and localization of perforations."(26) With these recommendations in mind, one could assume that a preoperative CBCT would be taken in any case involving endodontic retreatment, and almost certainly in a case requiring post removal, whether or not a guided procedure was planned. Other studies have taken into account the planning time necessary for guided procedures, specifically those requiring the fabrication of a 3D guide(17, 18, 21, 27-32). Connert et al. (2017) reported that the average planning time, including digital intraoral impression, virtual planning and design of a template, takes on average 9.4 min (ranging from 7 to 12.8 min). A second study by the same authors assessed the mean treatment duration which was reported to be 11.3 min when using the guide and 21.8 min otherwise(19). The authors noted that although planning time varied depending on the computer software, the learning curve was small and that with experience, the planning time is minimal. In contrast, dynamic guidance does not require a digital oral impression or scan, no planning/fabrication of an intraoral stent, thus the planning time would be considerably less than other static guided procedures. The results of their study showed the actual treatment time for static guided access procedures required only 30 s on average, which was similar to the 38.6 seconds average time for the dynamic post removal in this study. It should be noted that the 30 seconds treatment time in the previously mentioned study was to access the tooth using a static guide, whereas the 38.6 second average time in this study was to remove a fiber post, a considerably more involved procedure, this further attests to the efficiency of this dynamically guided procedure. In regards to planning/preparation times of guided procedures, the consensus among previous studies is that although it may seem to be time-consuming, chairside operating times and excessive loss of tooth structure are reduced, and the risk of iatrogenic damage is avoided(18, 27, 28, 30-34).

Dynamic guidance proved to be accurate in the removal of fiber posts. In comparison to the planned drill path trajectory, the actual performed drill trajectory deviated on average 1.13 degrees with an apical horizontal deviation of 0.29 mm. In the study by Zubizaretta et al, a comparison was made between statically guided, dynamically guided and manual access of teeth using essentially the same parameters for determining the accuracy of each technique as this study. The authors stated that the most relevant parameters analyzed in the study were the angular and apical deviations, because the apical deviation influences over the risk of root perforation and missed root canals and is directly related with the angular deviation because a high angular deviation increases the horizontal apical endpoint deviation(24). Drawing comparisons to other studies on guided endodontics is challenging as there are few studies on dynamic guidance and the accuracy measuring methods in ex vivo studies on statically guided procedures are heterogeneous(34). More studies with larger numbers of samples and a more standardized methodology are needed to draw conclusions on the precision of guided endodontics(34). That being stated, the accuracy of the dynamic guided trajectory in this study coincide with the results of Emery et al, which involved a surgeon experienced with dynamic navigation placing implants in models under clinical simulation using a dynamic navigation system. Their results showed the dynamic navigation system to have an angular deviation ranging from 0.89 to 1.26 degrees, and positional deviation at the apical extent of the trajectory to range from 0.36-0.56 mm(35). Buchgreitz et al suggested that a reasonable deviation of the bur can be classified as “acceptable” precision(36). In their study, the term “acceptable” was used when there was some deviation, but the canal could still be located and instrumented. In applying that principle to this study, “acceptable” would allow for some deviation while still allowing access to the apical gutta percha, in broad terms, this holds true, yet one must take into consideration that the range of acceptable deviation at the apical extent of an endodontic fiber post is quite narrow. Typically, endodontic fiber posts are placed to within 5mm of the apex(37), at this level root canal diameters range from 0.29 mm to 0.74 mm(38), and radicular dentin thickness at this level varies from 0.96mm to 2.7mm depending on the tooth and surface measured(39). Using these figures the average distance from the center of the root canal to the outside of the root ranges from 1.1mm to 3.44mm at the level of 4-5 mm from the apex. Thus, the horizontal apical deviation of 0.29 mm in this study would appear to be acceptable.

Within the limits of this study, using a dynamic guidance is both an efficient and accurate method to remove endodontic fiber posts.

Conclusions

Guided endodontics is an emerging field in dentistry. The endodontic application of a dynamic guidance system to remove endodontic fiber posts proved to be a reliable method, in terms of efficiency and accuracy to a level equivalent or superior to an expert clinician. This study also showed that the utilization of CBCT dynamic guidance allowed an inexperienced operator to perform a relatively challenging clinical procedure at a similar level of proficiency to an experienced endodontist. Dynamic navigation offers a novel protocol for fiber post removal, and may serve as a useful tool, especially in challenging clinical cases.

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