

The influence of three different instrumentation techniques on the incidence of postoperative pain after endodontic treatment

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Summary

Aims. Apical extrusion of infected debris to the periradicular tissues is one of the principal causes of postoperative pain and discomfort. Recent researches have shown that reciprocating instrumentation techniques seem to significantly increase the amount of debris extruded beyond the apex and, consequently, the risk of postoperative pain. The goal of the present study was to evaluate and compare postoperative pain using three different nickel-titanium instrumentation techniques: a rotary crown-down technique using TF instruments (SybronEndo, Orange, Ca), a reciprocating single-file technique using WaveOne instruments (Maillefer DENTSPLY, Ballaigues, CH), and a novel instrumentation technique (TF Adaptive, SybronEndo, Orange, Ca), using a unique, proprietary movement, combining reciprocation and continuous rotation.

Methods. Ninety patients requiring endodontic treatment on permanent premolar and molar teeth with non vital pulps preoperatively were included in the study. The patients were assigned into three groups of 30 patients each, trying to make the groups very similar, concerning the number of root canals, presence of initial pain and periapical lesions. The teeth in group 1 (n = 30) were instrumented with a crown-down technique using TF instruments, whilst those in group 2 (n = 30) were instrumented with a single-file technique using Waveone 08 25. The third group (n = 30) used the 3-file Tf Adaptive sequence. All techniques were performed following manufacturers' in-

structions and all canals were shaped, cleaned and obturated in a single-visit by the same operator. The assessment of postoperative pain was carried out at 3 days by using a visual analogue scale. VAS pain scores were compared using one-way ANOVA post hoc Tukey test. A value of $p < 0.05$ was required for statistical significance.

Results. Results for VAS pain scores showed a statistically significant difference was found between the WaveOne ($p=0,021$) technique and the other two techniques. No statistical significant differences were found between TF and TF Adaptive ($p= 0,087$).

When evaluating patient experiencing sever pain the incidence of symptoms was significantly higher with the WaveOne technique.

Conclusions. Since the incidence of preoperative pain, the type of tooth and the pulp and periodontal pathology were quite similar between the three tested groups, and all the other variables (operator, irrigation, obturation) were identical, we may conclude that the difference in postoperative pain can be mainly related to the different instrumentation techniques.

Key words: root canal treatment, pain, endodontic instruments.

Introduction

The completion of endodontic therapy can be done in a single appointment or with multiple visits. Clinical reports have shown that patients generally tolerate and prefer single-visit endodontic therapy (1-2). Therefore, single-visit root canal treatment has become a common practice also in non-vital cases, and offers several advantages, including a decreased number of operative procedures (3), and no risk of inter-appointment leakage through temporary restorations (1). In addition, single-visit root canal therapy is less time consuming and more economical; as a consequence, innovative manufacturing processes to produce better instruments (4-7), and new instrumentation techniques have been recently commercialized to improve simplicity and safety of treatment by using reciprocation motion instead of continuous rotation and by reducing the number of nickel titanium (NiTi) instruments and consequently instrumentation time (8-10).

More precisely, a few years ago Dentsply Maillefer (Ballaigues, Switzerland) and Dentsply VDW (Munich, Germany) have developed two different nickel titanium instruments of greater tapers (Waveone® and Reciproc®), which are designed to be used with an innovative, proprietary reciprocating movement, and allow root canals to be prepared with one single instrument: in the majority of cases a taper.08 size 25 instrumentis selected. The two above-mentioned instruments are slightly different in de-

sign and motion, but performance is quite similar (9-10). More recently, a new instrumentation technique (TF Adaptive®) has been developed by SybronEndo (Orange, Ca), aiming at combining the advantages of both continuous rotation and reciprocation. More precisely it is a patented, undisclosed, unique motion which automatically adapts to instrumentation stress. When the TF Adaptive instrument is not (or very lightly) stressed the movement can be described as a continuous rotation, allowing better cutting efficiency and removal of debris, since cross-sectional and flute design are meant to perform at their best in a clockwise motion (11-12). On the contrary while negotiating the canal, due to increased instrumentation stress and metal fatigue, the motion of the TF Adaptive instrument changes into a reciprocation mode, with specifically designed CW and CCW angles. Moreover these angles are not constant, but vary depending on the anatomical complexities and the intracanal stress. This "adaptive" motion is therefore meant to reduce the risk intracanal failure, without affecting performance, due to the fact that the best movement for each different clinical situation is automatically selected by the Adaptive motor.

The TF Adaptive technique is basically a 3-file technique, designed for all canals, with differences between small, difficult canals and large, easy ones, allowing in both cases an adequate taper and increased apical preparation. The number of instruments within the sequence can also vary and adapt to canal anatomy, being the last instrument of the sequence used only when a greater apical enlargement is needed due to larger original canal dimensions and/or enhanced final irrigation techniques. It is well known that a small, inadvertent extrusion of debris and irrigants into periapical tissues is a frequent complication during the cleaning and shaping procedures, both with manual stainless steel and nickel-titanium rotary instrumentation techniques (13-14). However, recent studies have shown that reciprocating instrumentation techniques seem to significantly increase the amount of debris extruded beyond the apex and, consequently, the risk of postoperative pain (15). A previous clinical study comparing Reciproc and NiTi rotary instruments has also confirmed these findings (16). Based on these premises, the goal of the present study was to evaluate and compare the incidence and intensity of postoperative pain using three different nickel-titanium instrumentation techniques: a rotary crown-down technique using Twisted Files (TF) instruments (SybronEndo, Orange, Ca), a reciprocating single-file technique using WaveOne instruments (Maillefer Dentsply, Baillagues, CH) and a novel instrumentation technique (TF Adaptive, SybronEndo, Orange, Ca.), using a unique, proprietary movement, combining reciprocation and continuous rotation.

Materials and methods

Ninety patients requiring endodontic treatment on permanent premolar and molar teeth with non vital pulps preoperatively were included in the study. These patients ranged in age from 19 to 73 years (average 46,5 years), and all were in good health, as determined from a written health history and oral interview. Patients who had previ-

ously taken antibiotics or analgesics were excluded. Age, gender, tooth location, pulp vitality and radiographically visible lesions were recorded. An electric pulp-testing device (Elements pulp vitality tester, Sybron endo, Orange, Ca) was used to assess pulp vitality.

Before initiating treatment, each tooth was examined according to clinical complaints, including the presence or absence of pain. Overall, 41 patients had symptomatic (preoperative pain) and 49 had asymptomatic teeth, respectively. Of the 90 teeth previously diagnosed as non-vital, 76 showed periapical lesions.

A single clinician evaluated all patients, using radiographic and clinical findings, and the same clinician was assigned for treatment of all cases. This procedure was performed to eliminate or minimize interpersonal variability in the treatment between clinicians.

The patients were assigned into three groups of 30 patients each, trying to make the groups very similar, concerning the number of root canals, presence of initial pain and periapical lesions. After isolation and access, the canals of all teeth were prepared using two different instrumentation techniques, irrigated with 5% NaOCl and 17% EDTA, and obturated with gutta percha and a zinc-oxide eugenol sealer using warm vertical compaction. The teeth in group 1 (n = 30) were instrumented with a crown-down technique using TF instruments, whilst those in group 2 (n = 30) were instrumented with a single-file technique, using WaveOne 08 25. The teeth in group 3 were instrumented using a TF Adaptive technique (n = 30), using both sequences for small or large canals depending on the initial tooth anatomy. All the three instrumentation technique strictly followed manufacturers' instructions. All canals were shaped, cleaned and obturated in a single-visit.

Although no systemic medication was prescribed, the patients were instructed to take mild analgesics (400 mg of ibuprofen), if they experienced pain. The assessment of postoperative pain was carried out at 3 days after initial appointment by one independent evaluator without knowledge of visit group under examination. The presence or absence of pain, or the appropriate degree of pain was recorded as none, slight, moderate, or severe, by using a visual analogue scale (VAS), validated in previous studies (3):

- No pain: the treated tooth felt normal. Patients don't have any pain.
- Mild pain: recognizable, but not discomforting, pain, which required no analgesics.
- Moderate pain: discomforting, but bearable, pain (analgesics, if used, were effective in relieving the pain).
- Severe pain: difficult to bear (analgesics had little or no effect in relieving the pain).

VAS pain scores were compared using one-way ANOVA post hoc Tukey test. A value of $p < 0.05$ was required for statistical significance.

Results

Results are shown in (Table 1). For VAS pain scores a statistically significant difference was found between the Wave One ($p=0,021$) technique and the other two tech-

Table 1. Overall incidence of post operative pain with TF, Reciproc and TF Adaptive instrumentation techniques.

Technique	No pain	Mild	Moderate	Severe
TF15 (50%)	7 (23,3%)	6 (20%)	2 (6,6%)	–
WaveOne	9 (30%)	5 (16,6%)	8 (26,6%)	8 (26,6%)
TF Adaptive	14 (46,6%)	8 (26,6%)	6 (20%)	2 (6,6%)

niques. No statistical significant differences were found between TF and TF Adaptive ($p=0,087$).

When comparing patients who developed no pain, TF and TF Adaptive instrumentation technique showed significantly better results. When evaluating patient experiencing severe pain the incidence of symptoms was significantly higher with the Wave One single-file technique.

Overall, severe pain occurred in 13,3% patients. More precisely, it occurred in 30% of patients treated with WaveOne and in 6,6% of patients treated with TF and TF Adaptive.

Discussion

Root canal preparation procedures are not easy to perform, due to anatomical complexities and limitations of the endodontic instruments, which often result in a high risk of intracanal failure and other iatrogenic errors (17-18). In most cases dentine chips, pulp tissue fragments, necrotic tissue, microorganisms and intracanal irrigants may be extruded from the apical foramen during the canal instrumentation. This is of concern since material extruded from the apical foramen may be related to inflammation of periapical tissue, postoperative pain and or to a flare-up (13-14). While there are statistical predictors of postoperative pain (nonvital teeth, patients already in pain, asymptomatic teeth with lesions, etc.), its occurrence is not inevitable, and to a large extent, can be avoided, by using proper instrumentation and irrigation techniques. Severe postoperative pain should be relatively uncommon. In large measure, its prevention is a function of providing excellent treatment, more precisely by creating a well-cleaned and shaped canal and by minimizing extrusion of canal contents during the process.

It is quite a common experience during endodontic instrumentation courses on extracted teeth, that participants visualize the creation of the "endodontic worm", a tubular mass of canal debris produced primarily by debris propelled through the apical foramen by forceful instrumentation, improper irrigation, and a lack of recapitulation. This worm is more likely to occur when reciprocation motion is used. In clinical practice this worm of debris includes bacteria, dentin chips, irrigants, and inflamed or dead pulp, that when pushed into the periapical tissues may elicitate postoperative pain.

In a previous study (16) a reciprocating single-file technique (Reciproc) was found to produce a more significant inflammatory response and pain when compared to a rotary nickel-titanium crown down instrumentation technique (TF). Since reciprocation movement is formed by a wider cutting angle and a smaller releasing angle, while rotating in the releasing angle, the flutes will not remove de-

bris but push them apically. Reciproc and WaveOne motion is very similar (even if not precisely disclosed by manufacturers), and this fact could also explain the higher incidence and intensity of postoperative pain that was found in the present study in the WaveOne group.

Moreover, both WaveOne and Reciproc techniques use a quite rigid, big single-file of increased taper (usually 08 taper, size 25), which directly reach the apex. In many cases, in order to reach the apical working length, reciprocating instruments are used with force directed apically, which makes an effective piston to propel debris from a patent apical foramen. Since instruments are used without any preliminary coronal enlargement. This results in a greater engagement of flutes and, consequently, more torque or applied pressure are needed. Moreover cutting ability of a reciprocating file is smaller when compared to a continuous rotation, and also debris removal is smaller, thus increasing the frictional stress and torque demand, due to entrapment of debris within the flutes (19).

The TF Adaptive technique has been proposed in order to maximize the advantages of reciprocation, while minimizing disadvantages, by using a unique, patented motion and a 3-file technique. The aim of a sequence is to reduce frictional stress and torque demand, while the patented adaptive motor selects automatically the best angles for best performance and safety. In the present study TF Adaptive technique showed very similar results to the TF instrumentation technique which utilize continuous rotation. No statistical significant differences were found between the two techniques for both incidence and intensity of postoperative pain. On the contrary both techniques were found to produce less post-operative pain when compared to the Reciproc technique. Since the incidence of preoperative pain, the type of tooth and the pulp and periodontal pathology were quite similar between the tested groups, and all the other variables (operator, irrigation, obturation) were identical, this difference was mainly related to the different instrumentation technique. These findings may be related to two different factors: the movement and the sequence.

Despite the fact that the angles are not closed by manufacturers, visual inspection and/or video recordings shows that the TF Adaptive motion is a reciprocating motion with cutting angles (CW angles) much greater than WaveOne movements. As a consequence the TF Adaptive instrument is working more time with a CW angle, which allows better cutting efficiency and removal of debris (and less tendency to push debris apically), because the flutes are designed to remove debris in a CW rotation. In such case TF Adaptive is taking advantage of the use of a motion that is more similar to continuous rotation for optimal debris removal. There are obviously some changes in the angles depending on canal anatomy (the

more complex, the smaller the CW angle), but they do not seem to significantly influence the overall result. On the contrary, these changes influence resistance to metal fatigue, since TF instruments used with the Adaptive motion were found to have superior resistance to cyclic fatigue when compared to the same TF instruments used in continuous rotation.

Moreover the use of a sequence and the use of more flexible NiTi instruments can be also a important factors in determining a lower incidence and intensity of postoperative pain, by reducing the amount of apical transportation and by avoiding to push debris by forcing instruments apically. TF instruments were found to be the most flexible Niti instruments, being significantly more flexible than ProTaper and M2, which are instruments with design and mass very similar to WaveOne and Reciproc (20-21).

In the most complex cases, the initial use of a small NiTi instrument (the Tf Adaptive sequence uses a.04 20 instrument, which can be considered as a reciprocating pathfinder) could be very useful. It has been shown with Reciproc and WaveOne instrumentation techniques that the use of a small Niti rotary pathfinder is very helpful in reducing iatrogenic errors, such as extrusion of debris and apical transportation (22).

Hence we may conclude that the new TF Adaptive technique is a unique reciprocating technique that is able to minimize the risk of pushing debris apically and consequently higher postoperative pain, a risk which is always present in a reciprocating motion (to a less or higher extent), due to the fact that in one sense of rotation the flutes remove debris, while in the opposite sense the debris are pushed apically.

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References

1. Sathorn C, Parashos P, Messer HH. Effectiveness of single-versus multiple-visit endodontic treatment of teeth with apical periodontitis: a systematic review and meta-analysis. *Int Endod J* 2005; 38:347-355.
2. Inamoto K, Kojima K, Nagamatsu K, Hamaguchi A, Nakata K, Nakamura H. A survey of the incidence of single-visit endodontics. *J Endod* 2002; 28:371-374.
3. Lohbauer U, Gambarini G, Ebert J, Dasch W, Petschelt A. Calcium release and pH-characteristics of calcium hydroxide plus points. *Int Endod J* 2005; 38:683-689.
4. Plotino G, Grande NM, Melo MC, Bahia MG, Testarelli L, Gambarini G. Cyclic fatigue of NiTi rotary instruments in a simulated apical abrupt curvature. *Int Endod J* 2010; 43:226-230.
5. Al-Sudani D, Grande NM, Plotino G, Pompa G, Di Carlo S, Testarelli L, Gambarini G. Cyclic fatigue of nickel-titanium rotary instruments in a double (S-shaped) simulated curvature. *J Endod* 2012; 38:987-989.
6. Plotino G, Grande NM, Mazza C, Petrovic R, Testarelli L, Gambarini G. Influence of size and taper of artificial canals on the trajectory of NiTi rotary instruments in cyclic fatigue studies. *Oral Surg* 2010; 109:60-66.
7. Testarelli L, Plotino G, Al-Sudani D, Vincenzi V, Giansiracusa A, Grande NM, Gambarini G. Bending properties of a new nickel-titanium alloy with a lower percent by weight of nickel. *J Endod* 2011; 37:5.
8. Kim HC, Kwak SW, Cheung GS, Ko DH, Chung SM, Lee W. Cyclic fatigue and torsional resistance of two new nickel-titanium instruments used in reciprocation motion: Reciproc versus WaveOne. *J Endod* 2012; 38:541-4.
9. Pedullà E, Grande NM, Plotino G, Palermo F, Gambarini G, Rapisarda E. Cyclic fatigue resistance of two reciprocating nickel-titanium instruments after immersion in sodium hypochlorite. *Int Endod J* 2012; 3 [Epub ahead of print]
10. Plotino G, Grande NM, Testarelli L, Gambarini G. Cyclic fatigue of Reciproc and WaveOne reciprocating instruments. *Int Endod J* 2012; 45:614-618.
11. Gambarini G, Gergi R, Naaman A, Osta N, Al Sudani D. Cyclic fatigue analysis of twisted file rotary NiTi instruments used in reciprocating motion. *Int Endod J* 2012; 45:802-806.
12. Gambarini G, Rubini AG, Al Sudani D, Gergi R, Culla A, De Angelis F, Di Carlo S, Pompa G, Osta N, Testarelli L. Influence of Different Angles of Reciprocation on the Cyclic Fatigue of Nickel-Titanium Endodontic Instruments. *J Endod* 2012; 38:1408-11.
13. Oginni A, Udoye C. Endodontic flare-ups: comparison of incidence between single and multiple visit procedures in patients attending a Nigerian teaching hospital. *BMC Oral Health* 2004; 4:4-6.
14. Siqueira JF, Jr Rocas IN, Favieri A, Machado AG, Gahyva SM, Oliveira JC, Abad EC. Incidence of postoperative pain after intracanal procedures based on an antimicrobial strategy. *J Endod* 2002; 28:457-460.
15. Bürklein S, Schäfer E. Apically extruded debris with reciprocating single-file and full-sequence rotary instrumentation systems. *J Endod* 2012; 38:850-2.
16. Gambarini G, Sudani DAL, Di Carlo S, Pompa G, Pacifici A, Pacifici L, Testarelli L. Incidence and intensity of postoperative pain and periapical inflammation after endodontic treatment with two different instrumentation techniques. *Eur J Inflam* 2012; 10:99-103.
17. Plotino G, Grande NM, Cordaro M, Testarelli L, Gambarini G. Measurement of the trajectory of different NiTi rotary instruments in an artificial canal specifically designed for cyclic fatigue tests. *Oral Surg* 2009; 108:152-6.
18. Plotino G, Grande NM, Cordaro M, Testarelli L, Gambarini G. Review of cyclic fatigue testing of nickel-titanium rotary instruments *J Endod* 2009; 35:1469-76.
19. De-Deus G, Barino B, Zamolyi RQ, Souza E, Fonseca A Jr, Fidel S, Fidel RA. Suboptimal debridement quality produced by the single-file F2 ProTaper technique in oval-shaped canals. *J Endod* 2010; 36:1897-900.
20. Gambarini G, Pongione G, Rizzo F, Testarelli L, Cavalleri G, Gerosa R. Bending properties of nickel-titanium instruments: a comparative study. *Min Stomat* 2008; 57:393-398.
21. Gambarini G, Gerosa R, De Luca M, Garala M, Testarelli L. Mechanical properties of a new and improved nickel-titanium alloy for endodontic use: aevaluation of file flexibility. *Oral Surg* 2008; 105:798-800.
22. Berutti E, Paolino DS, Chiandussi G, Alovisei M, Cantatore G, Castellucci A, Pasqualini D. Root canal anatomy preservation of WaveOne reciprocating files with or without glide path. *J Endod* 2012; 38:101-4.