The GuttaCore™ System:
Another Step Forward in the Evolution of Endodontics
SDR®
The Ideal Material for Bulk-Fill in High C-Factor Cavities

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SDR is the ideal material for bulk-fill in high C-factor cavities

SDR was introduced by DENTSPLY DeTrey, Konstanz, Germany in 2010 and has since been used in over 20 million restorations across the globe. SDR provides the dentist with a number of features and benefits, including low shrinkage stress which results in its ability to be applied in increments of 4mm. The SDR bulk-filling technique is suited for restoring deeper class I cavities with a high C-factor. A comparative study by Van Ende et al (2013) has examined micro tensile bond strength to dentin of the cavity floor: Only SDR was able to achieve a consistently high adhesion in 4mm deep cavities using the bulk filling technique without elaborate incremental layering. This was not possible with either a flowable or a conventional composite.

The modern bulk filling technique using a suitable composite restorative offers many advantages: a reliable marginal fit, low polymersiation shrinkage stress and avoidance of elaborate incremental layering—saving precious chair time and facilitating more cost-effective patient care. However, popular flowables and conventional composites are severely limited in terms of achievable increment thickness—usually only 1–2mm. A real breakthrough came in 2010, when DENTSPLY DeTrey introduced SDR, a low-viscosity composite restorative specially designed for the bulk-filling technique. This was the first material that allows reliable adaptation to the cavity wall with bulk increments up to 4mm in thickness. The SDR base is then covered with any methacrylate-based universal composite.

While conventional flowables can only be applied in small 1-2mm increments due to their high polymerisation shrinkage stress, placement of up to 4mm increments is possible with SDR. This is because a ‘polymersiation modulator’ is chemically embedded into the polymerisable resin back bone providing the necessary viscoelastic properties for low-stress polymerisation, which is considerably lower than in conventional composites. Thanks to SDR’s particularly high translucency, the polymerisation light safely penetrates all the way to the cavity bottom and initiates controlled polymerisation, even through 4mm increments.

Bulk-fill vs. incremental layering
The in-vitro study by Van Ende et al (2013), sets out to investigate the extent to which conventional incremental layering can be replaced by the simpler and time-saving bulk-filling technique, and which composites are suitable for this purpose. Another focus of their experimental study was the shape of the cavity. The typical narrow and deep cavities in class I restorations, which are difficult to reach for composite and curing light alike, were represented by appropriately prepared and classified experimental groups.

Materials and methods
The study examined the adhesion of the restoratives to the cavity-floor dentin. For this purpose, standardised class I restorations with different C-factors were restored with three different composite restoratives: a bulk-fill flowable, (SDR, DENTSPLY) a flowable (G-aenial Universal Flo, GC3), and a conventional paste-like composite (Z100, 3M ESPE4). The null hypothesis was neither the C-factor nor the restorative placement technique (incremental layering or bulk filling) had a significant influence on the micro tensile bond strength.

The three composite restoratives were assigned to four different experimental groups and applied in 96 differently prepared human first molars: in the bulk-filling technique in 4mm deep cavities with a C-factor of 5.57; in the bulk-filling technique in 2.5mm deep cavities with a C-factor of 3.86, in the conventional incremental layering technique (three equal layers with a total depth of 2.5mm, and a C-factor of 1.95); and in a free-hand build-up (height of 2.5mm, C-factor of 0.26) (see Figure 1).
After one week of storage in water at 37°C, eight specimens per group with a standard cross-sectional area of 1mm² were produced and examined for homogeneity and the presence of air bubbles at the matrices by light microscopy. Defective specimens were excluded from the trial. Error-free specimens were stressed to failure in a micro tensile bond-strength test. The testing data was evaluated statistically using the Kruskal-Wallis H-test, Weibull-analysis and Monte-Carlo-simulation.

Some samples with representative fractured surfaces were processed for more in-depth analysis by scanning electron microscope (SEM) to obtain further information on the nature of the failures – whether they occurred in the preliminary stages of the micro tensile bond-strength test or after exceeding the fracture limit.

Results
Analysis of the specimens prepared for the micro tensile bond strength test showed no significant differences between the different composites when these were filled incrementally into a cavity or freely build-up on flat surfaces. The opposite was true for the bulk-filling technique: Already at 2.5mm of cavity depth, pre-test failures occurred in 53% of the flowables and 100% of the composite specimens. At 4mm of cavity depth, all specimens of these two groups showed pre-test failures. The scanning electron microscope (SEM) analysis of the failures of the composite and flowable group when used in the bulk-filling technique were predominantly adhesive failures at the composite/dentin interface. This suggests that de-bonding may have occurred due to material shrinkage. On the other hand, all specimens produced with SDR resulted in 0% pre-test failures – adhesion was as high in deep class I cavities as on flat surfaces.

The testing of micro tensile bond strength couldn’t take place for the group of specimens that were produced with composite and only a limited number of specimens produced with the flowable composite (as the composite group had 100% pre-test failures at 2.5mm and 4mm, and the flowable group had 53% pre-test failures at 2.5mm and 100% at 4mm). The SDR specimens that were submitted for the micro tensile bond-strength test demonstrated consistently high micro tensile bond-strength in both 2.5mm and 4mm increments and failures only occurred when specimens were tested for micro tensile bond-strength at high MPa values.

Discussion and conclusions
Compared with the conventional layering technique, the bulk-filling technique provides significant advantages in direct restorations, provided that the filling material has low polymerisation stress, exhibits robust curing in the depth of the cavity, and bears enough mechanical strength to be used in the load-bearing posterior region. Bulk-filling deep class I or II cavities with traditional composite materials can be challenging, due to the cavities unfavourable geometry and high C-factor. The material chosen for such cavities should therefore exhibit suitable flow characteristics to facilitate complete adaptation to the deep cavity floor.

The results of the in-vitro study by Van Ende et al (2013) have shown that conventional composites and flowables are not suitable for bulk-filling. SDR, by contrast, can be recommended as dentin replacement/base in bulk-filling class I and II cavities. This material has sufficient mechanical strength for use in the posterior region and polymerises safely, even in deep cavities with a high C-factor. The excellent micro tensile bond strength to dentin indicates SDR’s good retention and adaptation to the dental hard tissues.

The study’s null hypothesis can be clearly refuted. The quality of a bulk filling depends significantly on the selected filling material and the geometry of the cavity. Only SDR achieved high micro tensile bond strength in the bulk filling technique, even in cavities with a very high C-factor, while the other two materials tested exhibited massive or even complete failures and proved appropriate only for the conventional incremental layering technique.

Summary
The success of an adhesive restoration utilising the bulk-filling technique is determined by the choice of material used. The scientific study by Van Ende et al (2013) demonstrates the significant differences between a conventional composite, flowable and bulk-fill composite in 2.5mm and especially in 4mm bulk fillings: The SDR restorative was the only material to achieve high adhesion to cavity floors in the presence of very different cavity geometries and depths.

References
1 Data on file
2 Van Ende, A et al.; 2013; Bulk-filling of high C-factor posterior cavities: Effect on adhesion to cavity bottom dentin. Dent Mater, Epub 2013 Dec 8
3 G-aenial Universal Flo is a registered trademark of GC
4 Z100 is a registered trademark of 3M ESPE
Carrier Based Gutta-Percha: for or against?

Carrier-based obturation (Thermafil®, ProTaper® Obturator) is one of the most popular techniques of root canal filling worldwide, which enjoys deserved recognition from leading authorities in the field of endodontics, including L. Stephen Buchanan, Giuseppe Cantatore, Julian Webber, Pierre Machtou, James L. Gutmann, and others. This simple and effective procedure significantly reduces the dentist’s working time while ensuring high-quality obturation, especially in narrow root canals and anatomically complex canals (Buchanan, 2009; Christensen G., 1991; Dummer PMH, Lyle L, Rawle J, Kennedy JK., 1994; Cantatore G., 2001) (Figs. 1, 2).

Many dentists are still prejudiced against the use of obturators, preferring lateral or vertical condensation instead. The main reason for this is the existence of various myths about carrier-based gutta-percha that often contradict each other.

Myth 1: Application of obturators causes periodontal burn, which is manifested by post-operative sensitivity. Therefore, the endodontic treatment will inevitably end in failure. In accordance with research results, temperature rise on the external surface of the root during the use of obturators is an average of 3.87°C, whereas for periodontal tissue damage it is necessary to increase the temperature by at least 10°C (Lipski M., 2004).

The post-operative pain occurring in some cases is caused by extrusion of the air from the root canal space into the periapical tissues during insertion of the obturator. Such sensitivity resolves spontaneously without subsequent development of any complications.

Myth 2: When obturators are used there is a high risk of gutta-percha extrusion beyond the apex.

Despite its simplicity, the carrier-based gutta-percha obturation technique follows strict rules of root canal preparation. An important stage is the gauging of the apical foramen, since using an obturator of a smaller diameter than that of the apical foramen may indeed lead to gutta-percha extrusion into the periapical tissues. However, when the root canal is prepared correctly and the instructions for carrier-based root canal obturation are followed accurately, the probability of extrusion is virtually eliminated.

Myth 3: Only the obturators carrier reaches the apex while the gutta-percha and sealer stay in the coronal and middle thirds of the canal.

This is a real possibility if the canal preparation, irrigation and carrier-based obturation techniques are not observed correctly. There are several key factors allowing for the prevention of this problem:

1. The root canal orifice must be sufficiently widened (funnel shape) for the obturator to enter freely, without losing gutta-percha at the canal entry.
2. The root canal must be properly disinfected. A vital condition for high-quality irrigation is the use of sodium hypochlorite and chemicals, such as a 15% - 17% EDTA (aqueous solution) or citric acid, to remove the smear layer created during canal preparation. This approach allows a high-quality obturation to be achieved in the main canals, as well as enabling the practitioner to fill ramifications (lateral canals, apical delta system, anastomoses between canals).
3. The coronal and middle thirds of the canal should be filled with a sealant ensuring that the obturator slides smoothly along its walls. At the same time, the sealant’s consistency should not be too dense. Epoxy-resin-based sealants are the ideal option such as AH Plus® (DENTSPLY), Adseal™ (Meta Biomed).
4. The obturator must be inserted into the root canal slowly and smoothly. Thermafill® obturators, with a .04 taper, are inserted into the canal over a period of 3 to 4 seconds. Obturators with a larger taper (ProTaper and WaveOne™) are inserted over a period of 6 to 8 seconds.

Using carrier-based gutta-percha allows predictable and successful results to be achieved in root canal obturation, as confirmed by numerous studies (Beatty et al., 1989; Dummer et al., 1993; Gençoglu et al., 1993; Gençoglu et al., 2002; Xu et al., 2007; Inan et al., 2007; Gençoglu et al., 2007; Saunders et al., 1994; Gutmann et al., 1993; Dalat et al., 1994; Pathomvanich et al., 1996; Abarca et al., 2007; Kontakiotis et al., 2007).

**Myth 4: It is difficult to remove obturators from the canal at retreatment.**

Many clinicians encounter problems when a carrier-based gutta-percha obturation needs to be removed. These problems are most often caused by the dentist lacking the appropriate tools. The relevant literature attests that removing an obturator filling from a canal takes less time than retreatment of a canal filled with gutta-percha (Frajlich, 1998; Royzenblat, Goodell, 2007). The optimum solution for these purposes is using nickel-titanium rotary instruments (ProFile® DENTSPLY). In my own practice I use ProTaper Universal Retreatment files (D series) (Fig. 3). Using these instruments it is possible to extract the obturator’s plastic carrier within one minute, after which removing gutta-percha residue from the canal walls becomes a fairly easy task.

**Fig. 3. ProTaper Universal D series instruments**

**Myth 5: A plastic obturator carrier impedes proper preparation of the post space.**

When preparing the canal for a post it is essential, before using the appropriately sized reamer, to remove the obturators carrier to the necessary depth. Practitioners often use diamond burs, ultrasonic tips and electrically heated pluggers such as System B™ (SybronEndo), Calamus® Dual (DENTSPLY), BeeFill® (VDW). However, in my opinion, the most predictable option is the application of dedicated Post Space Burs (DENTSPLY Maillefer) (Fig. 4). This bur is used in a turbine handpiece without water cooling; it allows removal of the plastic carrier in one movement from the root canal to the full-length of the post.

**Fig. 4. Post space bur**

**The GuttaCore System: Features and Use**

Based on the preconceptions set out above, the main claim against obturators is the presence of the plastic carrier within them. GuttaCore is the all-new concept of carrier-based gutta-percha (Fig. 5). GuttaCore obturator carriers are not made from plastic, but from a gutta-percha elastomer with intermolecular cross links (cross-linked gutta-percha). Thus, the obturator is made entirely of gutta-percha in two different forms (Fig. 6). This makes for not only rapid and high-quality three-dimensional root canal obturation, but also for easy post space preparation and root filling removal, in a case where retreatment is required. The carrier can be removed from the root canal just as easily as gutta-percha, since it is also gutta-percha. Consequently, for these purposes we can use the same instruments as in canals filled using lateral or vertical condensation.

**Fig. 5. GuttaCore obturators**

**Fig. 6. GuttaCore obturator structure**

Working with the GuttaCore system is very easy, but there are a series of key factors to avoid procedural errors. Below we set out a step-by-step sequence for the use of GuttaCore obturators.

1. The root canal must be properly shaped and disinfected.

The GuttaCore system is universal, i.e. it can be used regardless of which instruments were used to prepare the root canal. However, according to research results, after preparation root canals should have either a taper of no less than .06 or a large apical diameter. This is essential in order to ensure a high-quality irrigation and three-dimensional obturation (Boutsioukis C, Gogos C, Verhaagen B et al., 2010). When using the GuttaCore system, the root canal must be widened to at least size 20.06 or 25.04.

2. Select the right GuttaCore obturator diameter.

If a .06 or larger instrument was used to prepare the root canal, we would select an obturator of the same size as the final nickel-titanium file. If a .04 instrument was employed, we would select an obturator one size smaller (Table 1). Under no circumstances should any gutta-percha be cut off from the obturator as this may damage the carrier.

3. Gauging the root canal is a very important stage in ensuring predictable, high-quality three-dimensional obturation.

Each GuttaCore blister pack, which contains 5 obturators, also has a verifier of corresponding size and taper (Figs. 7, 8). This is a manual instrument which is passively inserted to the working length of the root canal. If the verifier does not passively fit to working length it can be used as a finishing file for apical enlargement.

Continued over page >>>
4. When using GuttaCore obturators, a thin layer of sealant is applied into the coronal, or in case of long root canals, the coronal and middle thirds of the canal. To apply the sealant we would employ a paper point, a probe or, in the case of using AH Plus® Jet™ sealant, a special mixing tip (Fig. 9). The pre-heated obturator, in the process of insertion into the root canal, evenly distributes the sealant along its walls. If there is excess sealant or it was applied to the full working length, there is a very high risk of sealant extrusion into the periapical tissues.

5. The working length is set on the obturator, after which it is placed into a holder of one of the ThermaPrep® 2 oven’s heating elements (Figs. 10, 11). The distinguishing characteristics of the ThermaPrep 2 oven are rapid three-dimensional heating of obturators, while maintaining the properties of the gutta-percha carrier, as well as the option of having both heating elements operating simultaneously. When working with the GuttaCore system, unlike obturators with a plastic carrier, a minimum heating level of 20-25 is set on the oven operating panel, regardless of the obturator size (Fig. 12).

The obturator is placed into the heating element by means of gently pressing down the holder. The oven operating cycle is automatically activated and an indicator light is switched on. The option of having both heating elements operating simultaneously makes it possible to heat up two obturators at a time, if necessary. When the heating is complete, the oven makes a sound signal, and the indicator light starts blinking. By pressing on the holder, the holder is released, the obturator is removed (Fig. 13) and slowly, without rotation, inserted into the root canal to the working length.

6. After the obturator is inserted into the root canal, the heated gutta-percha can be condensed with a plugger in the coronal part of the root canal. This generates additional hydrodynamic pressure, enabling the gutta-percha to better fill the ramifications of the main canal, such as the lateral canals, apical delta system and anastomoses between canals. During the condensation process, the obturator should be held firmly by the handle, preventing any displacement.
7. The final stage of obturation is the removal of the handle and the excess carrier above the orifice level. When using the GuttaCore system, there is no need to use a Therma-Cut bur for this purpose. We can either cut off the carrier at the orifice using a regular round bur or sharp hand excavator, or simply break it off using gentle lateral motions. To clean the gutta-percha and sealant residue from the tooth cavity, we can use a cotton ball soaked in chloroform or ethanol. To clean the gutta-percha and sealant residue from the tooth cavity, we can use a cotton ball soaked in chloroform or ethanol.

Conclusion
Endodontics is evolving along the lines of simplifying the technical part of procedures and reducing the dentist’s work time needed to perform them. There are new instruments, materials, devices and accessories being developed in order to reduce the number of working stages and make endodontic treatment less labour-intensive. At the same time, great attention must certainly be paid to ensure a simultaneous increase in the predictability of results and overall treatment success.

The development of the GuttaCore obturator is indeed a revolutionary step in the evolution of endodontics. This system can allow dentists to achieve high-quality three-dimensional obturation, quickly and without special effort, in situations where the dentist may encounter problems when applying other obturation techniques (Figs. 17, 18, 19).

References
2. Christensen G. Improved Thermafil concept well accepted. CRA Newsletter 1991;12:4
DENTSPLY is proud to announce new contemporary composite packaging.

DENTSPLY strive to make products that keep up with the times in addition to being safe and simple to use. As a consequence, DENTSPLY is pleased to announce a packaging redesign for CeramX® mono+, CeramX duo+, Spectrum® TPH3®, Dyract® XP, QuiXfil® and X-Flow® syringe and compule items. The outer cartons of both the syringe and compule items are to be replaced with fresh looking, space saving pouches. The new outer packaging offers protection against moisture and helps to prevent product counterfeiting. In addition to the changes in the outer packaging, all syringes have been updated, they will not only look more modern in shape, design and feature laser marked labels but they will also be more ergonomic to use. Their innovative laser marking will ensure that the labelling remains readable even after several rounds of wipe disinfection.

The new packaging will be available over a phased timeline from May 2014 to July 2014. Please refer to www.dentsplymea.com or your local DENTSPLY representative for more information.

AH Plus® receives top ratings from ecological consumer magazine.

The DENTSPLY DeTrey root canal sealing material, AH Plus has received top ratings for exceptional biocompatibility in comparative trials conducted by Germany’s ecological consumer magazine, ÖKO-TEST. Furthermore, a benefit versus risk assessment was conducted and AH Plus received the highest rating of “very good.” The highly rated products were identified by features such as “remaining practically unabsorbed by the body, are well tolerated by the tissue, and exhibit no adverse effects”. Out of the highly rated products, AH Plus was identified as the BEST of the sealers category and was considered as a state of the art adhesive filling material, characterised by a unique polyaddition reaction that forms neither an allergenic formaldehyde nor uses the hormonally active bisphenol-A.

DENTSPLY celebrated as PROTAPER NEXT™ claimed the “Excellence in clinical equipment” Award at the AEEDC exhibition, Dubai 2014. The Award commemorates dental products which are revolutionary in professional care or are ground breaking developments to existing products.

PROTAPER NEXT was declared the winner due to the innovation it brings to the DENTSPLY Maillefer PROTAPER system, which has been the gold standard in endodontics for many years. PROTAPER NEXT features the same variable taper design that clinicians have turned to for more than a decade, but has been refined to offer a shorter clinical sequence; requiring just two files for the majority of cases, greater flexibility and a unique patented design for improved performance and fully-tapered, predictable shaping.

Key features include:

- One torque setting, one speed setting and only two files per treatment for the majority of cases
- Swaggering action that reduces binding and improves debris removal
- Patented off-centre rectangular cross-section for greater strength and more space for debris removal
- M-Wire® NiTi alloy for increased flexibility and resistance to cyclic fatigue
- Faster shaping
- Single-use and pre-sterilised

PROTAPER NEXT is a complete system solution for all the steps of the endodontic procedure, contact us now at www.dentsplymea.com to see for yourself how the Award winning PROTAPER NEXT system can revolutionise your endodontic procedures.

Genios® teeth are German designed and engineered and therefore bear the mark of quality and precision. Their unique patented interdental closures ensure harmonious connections with anterior adjacent teeth, eliminating black interdental spaces and ensuring natural-looking papillae.

Key features:

- Five distinct design zones including cervical, neck, body, enamel and mamilons for life-like aesthetics
- 9 anterior upper & 6 anterior lower moulds, 9 posterior upper & lower moulds with 33° cuspation
- Available in 16 V-shades
- A unique interpenetrated polymer network (INPEN) structure for strength and durability

Genios teeth are complimented by Eclipse® light cure resin denture system and Lucitone 199® denture acrylic for traditional heat cure dentures.
Clinical guidelines for the use of PROTAPER NEXT™ instruments: part one

Peet J van der Vyver and Michael J Scianamblo discuss the clinical guidelines for using PROTAPER NEXT instruments

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Introduction

According to Bird, Chambers and Peters (2009), rotary nickel titanium instruments have become a standard tool for shaping root canal systems. These instruments provide the clinician with several advantages compared to conventional stainless steel instruments. For instance, they are more flexible, have increased cutting efficiency (Kim et al, 2012; Peters, 2004; Walia, Brantley, Gerstein, 1988), can create centred preparations more rapidly (Short, Morgan, Baumgartner, 1997; Glossen et al, 1995) and can produce tapered root canal preparations with a reduced tendency of canal transportation (Chen, Messer, 2002; Kim et al, 2012).

However, nickel titanium instruments appear to have a high risk of fracture (Arens et al, 2003; Sattapan et al, 2000) mainly because of flexural and torsional stresses during rotation in the root canal system (Berutti et al, 2003; Parashos, Messer, 2006).

When there is a wide area of contact between the cutting edge of the instrument and the canal wall during rotation, the instrument will be subjected to an increase in torsional stress (Blum et al, 1999). The preparation of a reproducible glide path can reduce the torsional stress on root canal instruments. A glide path is a smooth passage that extends from the canal orifice in the pulp chamber to its opening at the apex of the root (West, 2006). This will provide a continuous, uninterrupted pathway for the rotary nickel titanium instrument to enter and to move freely to the root canal terminus.

The main purpose of a glide path is to create a root canal diameter the same size as, or ideally a size bigger than, the first rotary instrument introduced (Berutti et al, 2004; Varela-patino et al, 2005; Berutti et al, 2009).

Another way to reduce torsional stress is to incorporate multiple progressive tapers to the instrument design for example the Protaper® Universal system (DENTSPLY/ Maillefer). According to West (2001), the progressive taper allows for only small areas of dentine to be engaged. This design concept also contributes to maintaining the original canal curvature (Yun, Kim, 2003).

PROTAPER NEXT

The PROTAPER NEXT system was recently launched into the dental market. There are five instruments in the system but most canals can be prepared by using only the first two.

This system also makes use of the multiple progressive taper concept. Each file presents with an increasing and decreasing percentage tapered design on a single file concept (Ruddle, Machtou, West, 2013). The design ensures that there is reduced contact between the cutting flutes of the instrument and the dentine wall, thus reducing the chance for taper lock (screw-in effect). At the same time, it also increases flexibility and cutting efficiency (Ruddle, 2001).
The first instrument in the system is PROTAPER NEXT X1 (Figure 1), with a tip size of 0.17mm and a 4% taper. This instrument is used after creation of a reproducible glide path by means of hand instruments or rotary Pathfiles™. This instrument is always followed by the second instrument, the PROTAPER NEXT X2 (0.25mm tip and 6% taper) (Figure 2). PROTAPER NEXT X2 can be regarded as the first finishing file in the system, as it leaves the prepared root canal with adequate shape and taper for optimal irrigation and root canal obturation. PROTAPER NEXT X1 and X2 have an increasing and decreasing percentage tapered design over the active portion of the instruments.

The last three finishing instruments are PROTAPER NEXT X3 (0.30mm tip with 7% taper) (Figure 3), PROTAPER NEXT X4 (0.40mm tip with 6% taper) (Figure 4) and PROTAPER NEXT X5 (0.50mm tip with 6% taper) (Figure 5). These instruments have a decreasing percentage taper from the tip to the shank. PROTAPER NEXT X3, X4 and X5 can be used to either create more taper in a root canal or to prepare larger root canal systems.

Another benefit of this system is the fact that the instruments are manufactured from M-wire® and not traditional nickel titanium alloy. Research by Johnson et al (2008) demonstrated that the M-wire alloy could reduce cyclic fatigue by 400% compared to similar instruments manufactured from conventional nickel titanium alloys. The added metallurgical benefit contributes towards more flexible instruments, increased safety and protection against instrument fracture (Gutmann, Gao, 2012).

The last major advantage towards root canal preparation with the PROTAPER NEXT system is the fact that most of the instruments present with a bilateral symmetrical rectangular cross section (Figure 6) with an offset from the central axis of rotation (except in the last 3mm of the instrument, D0-D3). The exception is PROTAPER NEXT X1, which has a square cross section in last 3mm to give the instruments with a bit more core strength in the narrow apical part. This design characteristic allows the instrument to experience a rotational phenomenon known as precession or swagger (Scianamblo, 2011). The benefits of this design characteristic include:

- It further reduces (in addition to the progressive tapered design) the engagement between the instrument and the dentine walls. This will contribute to a reduction in taper lock, screw-in effect and stress on the file
- Removal of debris in a coronal direction (Figure 7) because the off-centre cross-section allows for more space around the flutes of the instrument. This will lead to improved cutting efficiency, as the blades will stay in contact with the surrounding dentine walls. Root canal preparation is done in a very fast and effortless manner
- The swaggering motion of the instrument initiate activation of the irrigation solution during canal preparation, improving debris removal
- Reduced risk of instrument fracture because there is less stress on the file and more efficient debris removal
- Every instrument is capable of cutting a larger envelope of motion (larger canal preparation size) (Figure 6) compared to a similarly sized instrument with a symmetrical mass and axis of rotation. This allows the clinician to use fewer instruments to prepare a root canal to adequate shape and taper to allow for optimal irrigation and obturation
- There is a smooth transition between the different sizes of instruments because the design ensures that the instrument sequence itself expands exponentially.

Clinical guidelines for PROTAPER NEXT instruments

The clinical technique for PROTAPER NEXT will be discussed by means of case reports. The first case report will outline the basic guidelines for the use of PROTAPER NEXT instruments.

The patient, a 64-year-old male, presented with a previous emergency root canal treatment on his upper left first premolar. A periapical radiograph showed evidence of three separate roots and large periapical lesion (Figure 8). According to the patient, the tooth was left open by his dentist who had performed the emergency root canal treatment to allow for drainage.
Guideline one: create straight-line access and remove triangles of dentine

It is very important to prepare an adequate access cavity that will ensure straight-line access into each root canal system. However, in the present clinical case there was still a dentine triangle obscuring direct access into the distobuccal root canal system (Figures 9a and 9b). The Start-X tip no. 3 was used to remove some of this dentine on the pulp floor (Figure 10), allowing more direct access to the distobuccal root canal orifice.

A Micro-opener (DENTSPLY/Maillefer) – size 10, 06% taper – instrument was used to locate and enlarge the distobuccal root canal orifice.

Guideline two: negotiate canal to patency and create a reproducible glide path

The authors prefer to negotiate the root canal with size 08 or 10 K-files until apical patency is established (Figure 13a). Apical patency is the ability to pass small K-files (0.5-1mm) passively through the apical constriction, beyond the minor diameter without widening it (Buchanan, 1989). Length determination was done using a Propex Pixi apex locator (DENTSPLY/Maillefer). Predictable readings were achieved by using two size 10 K-files in the mesiobuccal and distobuccal root canals and a size 20 K-file in the larger palatal root canal and confirmed radiographically (Figure 13b). After working length determination, a reproducible glide path should be established. It is recommended to use the stainless steel K-files in vertical in and out motion with an amplitude of 1mm and gradually increase the amplitude as the dentine wall wears away and the file advances apically (West, 2006). West (2010) recommends a ‘super loose’ size 10 K-file as the minimum requirement.
To confirm that a reproducible glide path is present, the size 10 file is taken to full working length (Figure 14a). The file is then withdrawn 1mm and should be able to slide back to working length by using light finger pressure. Thereafter, the file is withdrawn 2mm and should be able to slide back to working length, using the same protocol. When the file can be withdrawn 4mm to 5mm and slid back to working length (Figure 14b), a reproducible glide path is confirmed (Van der Vyver, 2011).

The reproducible glide path is then enlarged using rotary Pathfiles (DENTSPLY/Maillefer). Pathfile no. 1 (0.13mm tip size) is taken to full working length, operating at 300rpm and 5N/cm torque (Figure 15a). As soon as the file reaches working length, the authors recommend to brush lightly outwards (away from any external root concavities). This motion will create more lateral space, remove restrictive dentine at this level at working length and incorporate a deliberate backstroke, outward brushing motion (away from any external root concavities) to create more space in the coronal aspect of the root canal. (Figure 15b).

When using PROTAPER NEXT, it is only necessary (in most cases) to enlarge the glide path to the second Pathfile (0.16mm) as the first preparation instrument, the X1 of the PROTAPER NEXT system has a tip size of ISO 17. However, it is recommended to use Pathfile no. 3 (0.19mm tip size) when dealing with challenging root canal systems.

Guideline three: PROTAPER NEXT preparation sequence

Introduce sodium hypochlorite and the PROTAPER NEXT X1 instrument into the root canal. The authors found that four scenarios can present when using the PROTAPER NEXT X1 instrument:

1. Easy root canals
2. More difficult and longer root canals
3. Very long/severely curved root canals
4. Larger diameter root canals and retreatment cases root canals where the use of PROTAPER NEXT X1 is not necessary and canal preparation can be initiated with PROTAPER NEXT X2, X3, X4 or X5. The last two scenarios will be discussed later in this article.

For easy canals (mesiobuccal root canal in this case report), allow the PROTAPER NEXT X1 instrument (operating at 300rpm and torque of 2.8N/cm) to slide down the glide path up to working length (Figure 16a). If this is possible, pull the instrument back to approximately 2-3mm short of WL and a deliberate backstroke, outward brushing motion incorporated (away from any external root concavities) to create more space in the coronal aspect of the root canal. (Figure 16b). Finally, take the file to full working length and ‘touch’ the apex and brush outwards (coronally) with the file in the apical third of the root canal. This ‘touch-and-brush’ sequence can be repeated up to three or four times (Figure 16c).

For more difficult and longer canals (distobuccal root canal in this case report), allow the PROTAPER NEXT X1 to slide down the glide path until resistance is met (Figure 17a). Incorporate a deliberate backstroke, outward brushing motion in order to remove restrictive dentine at this level (away from any external root concavities). This motion will create more lateral space, enabling the file to slide a few more millimetres down the root canal towards working length (Figure 17b) (if the file ceases to progress apically, remove the file, clean the flutes, irrigate, recapitulate and re-irrigate the canal before you progress with the shaping procedure). This procedure is repeated until the file reaches full working length. Finally, take the file to full working length (Figure 17c) and the ‘touch-and-brush’ sequence is done three to four times in order to complete canal preparation.

Figs. 14a-b. Reproducible glide path confirmation. Figure 14a shows a size 10 K-file is taken to full working length. Figure 14b shows a size 10 K-file withdrawn 4mm to 5mm and slid back to working length using light finger pressure.

Figs. 15a. Pathfile no. 1 is taken to full working length
Figs. 15b. Pathfile no. 2 is taken to full working length

Figs. 16a-c. Preparation sequence for easy canals. Figure 16a shows PROTAPER NEXT X1 (operating at 300rpm and torque of 2.8N/cm) slid down the glide path and able to reach working length. Figure 16b shows the instrument pulled back to approximately 2-3mm short of WL and a deliberate backstroke, outward brushing motion incorporated (away from any external root concavities) to create more space in the coronal aspect of the root canal. Figure 16c shows the instrument taken to full WL and a ‘touch-and-brush’ sequence done three to four times in order to complete canal preparation.

Figs. 17a-c. Preparation sequence for more difficult or longer canals. Allow the PROTAPER NEXT X1 to slide down the glide path until resistance is met. Incorporate a deliberate backstroke, outward brushing motion in order to remove restrictive dentine at this level at this level (Figure 17a). Increased lateral space will enable the file to slide a few more millimetres down the root canal towards working length and the brushing cycle is repeated (Figure 17b). When the file reaches full WL, the ‘touch-and-brush’ sequence is done three to four times to complete canal preparation (Figure 17c).
After the use of PROTAPER NEXT X1, it is recommended to irrigate with sodium hypochlorite, recapitulate with a small patency file to dislodge cutting debris and to re-irrigate to flush out all the dislodged debris from the root canal (Figures 18a-c).

PROTAPER NEXT X2 (first finishing instrument)
Use PROTAPER NEXT X2 (25/06) to full working length, using the same protocol as described above. However, it is recommended to use the ‘touch-and-brush’ sequence in the apical part of the root canal only two to three times as a final step (Figure 19). Excessive ‘touch-and-brush’ sequences in the apical part of the root canal can lead to transportation of the root canal. The root canal is again irrigated, recapitulated and re-irrigated. Gauging of apical foramen to determine if the preparation is complete.

If it is found that the 30/02 instrument fits tight, but short of the full working length (Figure 22a), it is recommended to continue canal preparation with the PROTAPER NEXT X3 (30/07) (Figure 22b) and gauge again with the 30/02 nickel titanium hand instrument (Figure 22c).

Guideline four: shaping recommendations for PROTAPER NEXT X3, X4 and X5
PROTAPER NEXT X3 (as well as X4 and X5 if necessary) is used in the same manner as PROTAPER NEXT X1 or X2 with the exception that the apical preparation is done by using the ‘touch-and-brush’ sequence only once or twice in the apical third of the root canal. Apical gauging is done according to the above mentioned protocol using a size 30/02, 40/02 or 50/02 nickel titanium instruments.

The 30/02 instrument was fitting snug at working length in the palatal root canal in the present case report. The canals were obturated with PROTAPER NEXT X2 gutta percha points in the mesiobuccal and distobuccal root canals and a PROTAPER NEXT X3 gutta percha point in the palatal root canal as master cones using the Calamus Dual Obturation Unit (DENTSPLY/Maillefer). Figure 23 demonstrates the final result after canal obturation.
Preparation sequence for very long and curved root canals

In selected clinical cases, the clinician might find that PROTAPER NEXT X1 does not progress to full working length even after a few coronal circumferential brushing motions. The authors then recommend to create more coronal shape by using PROTAPER NEXT X1 followed by PROTAPER NEXT X2 up to two thirds of the canal length. This preparation sequence will create enough lateral space in the coronal two thirds of the root canal to ensure that PROTAPER NEXT X1 can now be taken to full working length without any difficulty.

Case report

The patient, a 50-year-old female, presented with pain on her mandibular right first molar with a history of previous emergency root canal treatment. Clinical examination revealed a broken down and leaking temporary restoration, possibly resulting in coronal leakage. A periapical radiograph revealed very long and curved mesial roots. Also visible on the radiograph was evidence of dentine triangles, preventing straight-line access into the mesial root canals (Figure 24).

The defective temporary restoration and caries were removed before the tooth was restored with composite and a new access cavity prepared. Note the evidence of dentine triangles on the mesial aspect of the canal orifices (Figure 25). The dentine triangles were removed with a Protaper SX instrument, ensuring straight-line access into all the root canals. Figure 26 shows the radiographic view of the length determination confirming straight-line access into the root canals.

As mentioned before, the clinical protocol for cases with very long and curved root canals would be to allow PROTAPER NEXT X1 to progress to about two thirds of the canal length (Figure 27a). This is followed by irrigation, recapitulation and re-irrigation sequence with sodium hypochlorite. PROTAPER NEXT X2 is then used in the same manner (with circumferential outstroke brushing motions) to the same length (Figure 27b). PROTAPER NEXT X1 is then used again to progress with canal preparation to full working length (Figure 27c) using the ‘touch-and-brush’ sequence as described before. PROTAPER NEXT X2 is taken to full working length (using the same protocol as described before) (Figure 27d) after irrigation, recapitulation and re-irrigation of the root canal.

Canals were gauged according to the technique described before and final preparation was done up to PROTAPER NEXT X2 in the mesial root canals and up to PROTAPER NEXT X3 in the distal root canal. Guttacore™ verifiers were fitted (Figure 28a) to working length to confirm the size of obturators for each canal before the canals were obturated with corresponding Guttacore obturators. Figure 28b shows the postoperative result after obturation.

Shaping recommendations for large diameter root canals or retreatment of root canals

If the first file to working length is a size 20 K-file and it is loose up to working length, the shaping procedure can be initiated by using PROTAPER NEXT X2 (25/06). If the first files to length are a size 25/30, 30/35 or 40/45 and they are found to be loose in the canal up to working length, the shaping procedure can be initiated with PROTAPER NEXT X3 (30/07), X4 (40/06) and X5 (50/06) respectively.
Achieving a balance between implant-supported restoration aesthetics and maintaining periodontal health is important in an overall successful outcome of the prosthesis. The goal is to create an emergence profile design that allows for minimal tissue displacement while achieving optimal cervical contours for aesthetics. It is important in the design to allow access for proper cleaning by the patient and clinician (Fig. 1).

There are two types of implant restoration designs commonly used in single-tooth replacement prosthetics. They are a screw-retained crown or a two-piece abutment and cement-retained crown. The screw-retained crown design is the technique more commonly used in Europe. Whereas, the cement retained crown prosthesis is more frequently used in the United States.

The two-piece abutment and cement-retained crown restoration has an abutment that is designed to provide the subgingival emergence profile and allows the crown to be cemented onto the abutment (Fig. 2). The emergence profile refers to the subgingival contours that lie between the implant platform and the emerging abutment and crown (Sarmont, 2009). Using a custom designed abutment provides greater flexibility in determining the proper shape of the emergence profile compared with pre-fabricated standard abutment design.

To obtain a pleasing restoration, the subgingival contours must start at the small circle of the implant head and emerge from the tissue with an anatomical profile (Sarmont, 2009). The result should be an emergence profile that allows for minimal displacement of the surrounding tissue while creating an aesthetically pleasing appearance (Fig. 3). This design allows for easy access into the implant sulcus area so cleaning and maintaining can be easily achieved by both the patient and the clinician. Over or under contouring of the abutment and/or restoration can result in biofilm retention and peri-implantitis. It is important for the emergence profile to resemble that of a natural tooth. Often the adjacent teeth can be used as a guide to determine the proper contours.
The protocol for margin location of a standard implant restoration is still under debate. As the location of the crown abutment margin is placed deeper subgingival, the ability to access and maintain the site become more difficult (Linkevicius, 2012). What does this all mean for the clinician and patient in the maintenance of the implant prosthesis?

Access to the subgingivally area of the implant prosthesis for proper maintenance is vital to the health and success rate of the prosthesis. As margin location and emergence profiles extend farther subgingival, the ability to maintain these sites becomes more challenging. Evidence has shown that power scalers with non-metallic tips can be beneficial in maintaining the implant prosthesis (Sato, 2004). Several manufacturers offer tip designs that will accommodate the different types of power scalers. DENTSPLY Professional has an insert whose unique design allows a polymer sleeve to be assembled to the active tip area of this ultrasonic implant insert (Fig. 4). When fully assembled, the Cavitron® SoftTip™ Ultrasonic Implant Insert can easily be incorporated into a clinicians’ implant maintenance procedure.

Incorporating ultrasonic scaling into the implant maintenance protocol may have several benefits. Combining mechanical movement and lavage can aid in the removal of biofilm and other debris in the implant prosthesis sulcus. Wilkins wrote in 2012: “Studies indicate cavitation is capable of destroying surface bacteria and can remove endotoxin from the root surface.” Additionally: “Oscillation of the ultrasonic tip causes hydrodynamic waves to surround the tip. This acoustic turbulence is believed to have a disruptive effect on surface bacteria” (Wilkins, 2012). Multiple in vitro studies have discussed that cavitation may have the potential to disrupt the cell wall of the bacteria, and acoustic turbulence is believed to have disruptive effect on the surface bacteria (Baehni, 1992; McInnes, 1993; Walmsley, 1990). However, further in vivo studies need to be conducted to determine if the same outcomes are achieved in the sulcus.

Another benefit to incorporating power scaling into the maintenance procedure is the ability to adapt the active tip area into the implant sulcus. Incorporating vertical adaptation of the active tip, at a 0 to 15-degree angle, to the implant restoration can allow for significant subgingival surface contact for efficient deposit removal. When the emergence profile follows the anatomical shape of a natural tooth, this instrumentation technique can be an effective method of maintaining the site.

Finally, easy access for the patient is extremely important in the success of the implant prosthesis. There are a variety of interdental brushes, cleaners, and floss options available to the patient. It is important that the cleaners be easy to use, not cause tissue trauma in the implant sulcus, or surface damage to the aesthetic materials in the restoration.

Dental implants are increasing in demand in part by their high success rates and the improved aesthetics they provide the patient. A key to this success is having the proper design incorporated into the restoration. When designed properly, the implant restoration can be easily maintained by both the patient and clinician.

**About the authors**

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