ProTaper NEXT™
5th Generation Technology
Dyract®
Differentiated for over 20 years
Use SDR in combination with the improved handling and modelling performance of Ceram•X mono+ to achieve a simplified, aesthetic restoration.

SDR is the first bulk-fill flowable composite base material offering unique self-levelling and cavity adaption with up to 40% time-saving over conventional layering composites. 18 million restorations have been placed globally with SDR*.

The simplicity and natural aesthetics of Ceram•X mono+ make it the perfect composite partner for SDR.

*Data on file

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The Shaping Movement
5th Generation Technology
by Dr. Clifford J. Ruddle, DDS | Prof. Pierre Machtou, DDS | Dr. John D. West, DDS

Since the beginning of modern day endodontics, there have been numerous concepts, strategies, and techniques for preparing canals. Over the decades, a staggering array of files has emerged for negotiating and shaping canals. In spite of the design of the file, the number of instruments required, and the surprising multitude of techniques advocated, endodontic treatment has been typically approached with optimism for probable success.

The clinical endodontic breakthrough was progressing from utilising a long series of stainless steel (SS) hand files and several rotary Gates Glidden drills to integrating nickel titanium (NiTi) files for shaping canals. Regardless of the methods utilised, the mechanical objectives for canal preparation were brilliantly outlined almost 40 years ago by Dr. Herbert Schröder.¹ When properly performed, these mechanical objectives promote the biological objectives for shaping canals, 3-D disinfection, and filling root canal systems (Figure 1).

The purpose of this article is to identify and compare how each new generation of endodontic NiTi shaping files served to advance canal preparation methods. Importantly, this paper will identify a new file system and describe a clinical technique that combines the most proven design features from the past with the latest innovations presently developed.

NiTi Shaping Movement
In 1988, Walia proposed Nitinol, a NiTi alloy for shaping canals, as it is 2-3 times more flexible, in the same file sizes, compared to stainless steel.² A game-changing outcome of files manufactured from NiTi was that curved canals could be mechanically prepared utilising a continuous rotary motion. By the mid-1990s, the first commercially available NiTi rotary files had come to market.³ The following is a mechanical classification of each generation of file systems. Rather than identify the myriad of available cross-sections, files will be characterised as having either a passive vs. an active cutting action.

First Generation
To appreciate the evolution of NiTi mechanical instruments, it is useful to know that, in general, first generation NiTi files have passive cutting radial lands and fixed tapers of 4% and 6% over the length of their active blades (Figure 2).⁴ This generation of technology required numerous files to achieve the preparation objectives.
By the mid to late 1990s, GT files (Dentsply Tulsa Dental Specialties) became available that provided a fixed taper on a single file of 6%, 8%, 10%, and 12%. The single most important design feature of first generation NiTi cutting instruments is they have active cutting edges and require fewer instruments to fully prepare a canal (Figure 3). To discourage taper lock and the resultant screw effect associated with both passive and active fixed tapered NiTi cutting instruments, EndoSequence (Brassler USA) and BioRaCe (FKG Dentaire) provide file lines with alternating contact points. Although this feature is intended to mitigate taper lock, these file lines still have a fixed tapered design over their active portions. The clinical breakthrough occurred when ProTaper (Dentsply Tulsa Dental Specialties) came to market utilising multiple increasing or decreasing percentage tapers on a single file. This revolutionary, progressively tapered design limits each file’s cutting action to a specific region of the canal and affords a shorter sequence of files to safely produce deep Schilderian shapes (Figure 4).

Second Generation
The second generation of NiTi rotary files came to market in 2001. The critical distinction of this generation of instruments is they have active cutting edges and require fewer instruments to fully prepare a canal (Figure 3). To discourage taper lock and the resultant screw effect associated with both passive and active fixed tapered NiTi cutting instruments, EndoSequence (Brassler USA) and BioRaCe (FKG Dentaire) provide file lines with alternating contact points. Although this feature is intended to mitigate taper lock, these file lines still have a fixed tapered design over their active portions. The clinical breakthrough occurred when ProTaper (Dentsply Tulsa Dental Specialties) came to market utilising multiple increasing or decreasing percentage tapers on a single file. This revolutionary, progressively tapered design limits each file’s cutting action to a specific region of the canal and affords a shorter sequence of files to safely produce deep Schilderian shapes (Figure 4).

During this period, manufacturers began to focus on other methods to increase the resistance to file separation. Some manufacturers electropolished their files to remove surface irregularities caused from the traditional grinding process. However, it has been clinically observed and scientifically reported that electropolishing dulls the sharp cutting edges. As such, the perceived advantages of electropolishing were offset by the more undesirable inward pressure required to advance a file to length. Excessive inward pressure, especially when utilising fixed tapered files, invites taper lock, the screw effect, and excessive torque on a rotary file during work. To offset deficiencies in general, or inefficiencies resulting from electropolishing, more cross-sectional designs have become available and increased, yet more dangerous, rotational speeds are advocated.

Third Generation
Improvements in NiTi metallurgy became the hallmark of what may be identified as the 3rd generation of mechanical shaping files. In 2007, manufacturers began to focus on utilising heating and cooling methods to reduce cyclic fatigue and improve safety when rotary NiTi instruments work in more curved canals. The desired phase-transition point between martensite and austenite can be identified to produce a more clinically optimal metal than NiTi, itself. This 3rd generation of NiTi instruments significantly reduces cyclic fatigue and, hence, broken files. Examples of brand lines that offer heat treatment technology are Twisted File (SybronEndo), Hyflex (Coltene Whaledent) and GT, Vortex, and WaveOne (Dentsply Tulsa Dental Specialties).

Fourth Generation
Another advancement in canal preparation procedures utilises reciprocation, which may be defined as any repetitive up-and-down or back-and-forth motion. This technology was first introduced in the late 1950s by the French dentist, Blanc. Currently, the M4 (SybronEndo), Endo Express (Essential Dental Systems), and Endo-Eze (Ultradent) are examples of systems that use a movement where the clockwise (CW) and counterclockwise (CCW) degrees of rotation are absolutely equal. As compared to full rotation, a reciprocating file that utilises an equal bidirectional movement requires more inward pressure to progress, will not cut as efficiently as a same-size rotary file, and is more limited in augering debris out of the canal.

From these earlier experiences, innovation in reciprocation technology led to a 4th generation of instruments for shaping canals. This generation of instruments and related technology has largely fulfilled the long hoped-for single-file technique. ReDent-Nova (Henry Schein) introduced the Self Adjusting File (SAF). This file has a compressible open tube design that is purported to exert uniform pressure on the dentinal walls, regardless of the cross-sectional configuration of the canal. The SAF is mechanically driven by a handpiece that produces both a short 0.4mm vertical amplitude stroke and vibrating movement with constant irrigation. Another emerging single-file technique is termed One Shape (Micro Mega), to be mentioned further in 5th generation designs.

By far the most popular single-file concept is termed WaveOne (Dentsply Tulsa Dental Specialties and Maillefer) and Reciproc (VDW). WaveOne represents a convergence of the best design features from the 2nd and 3rd generation of files, coupled with a reciprocating motor that drives any given file in unequal bidirectional angles. The CCW engaging angle is 5 times the CW disengaging angle and is designed to be less than the elastic limit of the file. Strategically, after 3 CCW and CW cutting cycles, the file will have rotated 360°, or one circle (Figure 5). This novel reciprocating movement allows a file to more readily progress, efficiently cut, and effectively auger debris out of the canal.

Continued over page >>>
The 5th generation of shaping files has been designed such that the centre of mass and/or the centre of rotation are offset (Figure 6). In rotation, files that have an offset design produce a mechanical wave of motion that travels along the active length of the file. Like the progressively percentage tapered design of any given ProTaper file, this offset design serves to further minimise the engagement between the file and dentin. In addition, an offset design enhances augering debris out of a canal and improves flexibility along the active portion of a PTN file. The advantages of an offset design will be discussed later in this article.

ProTaper Next

There are 5 ProTaper Next (PTN) files (Dentsply Tulsa Dental Specialties) available, in different lengths, for shaping canals, namely X1, X2, X3, X4, and X5 (Figure 7). In sequence, these files have yellow, red, blue, double black, and double yellow identification rings on their handles, corresponding to sizes 17/04, 25/06, 30/07, 40/06, and 50/06, respectively. The tapers just listed are NOT fixed over the active portion of any given PTN file. Appreciate the PTN X1 and X2 files have both an increasing and decreasing percentage tapered design on a single file; whereas the PTN X3, X4, and X5 files have a fixed taper from D1-D3, then a decreasing percentage tapered design over the rest of their active portions.

PTN files are the convergence of 3 significant design features, including progressive percentage tapers on a single file, M-wire technology, and the 5th generation of continuous improvement, the offset design. As a single example, the PTN X1 file has a centered mass and axis of rotation from D1-D3, whereas from D4-D16, the X1 file has an offset mass of rotation. Starting at 4%, the X1 file has 10 increasing percentage tapers from D1-D11; whereas, from D12-D16, there are decreasing percentage tapers to enhance flexibility and conserve radicular dentin during shaping procedures.

The PTN files are used at 300 rpm and a torque of 2.0-5.2 Ncm, based on the method of use. However, the authors prefer a torque of 5.2 Ncm, as this level of torque has been validated as profoundly safe if clinicians perform meticulous glide path management procedures and utilise a deliberate outward brushing motion when progressively shaping canals. In the PTN technique, all files are used in exactly the same way and the sequence always follows the ISO color progression and is always the same regardless of the length, diameter, or curvature of a canal.

ProTaper Next Shaping Technique

The ProTaper Next shaping technique is extraordinarily safe, efficient, and simplistic when attention is focused on the access preparation and glide path management (GPM). As is required for any shaping technique, straightline access to each orifice is emphasised. Attention is directed to flaring, flattening, and finishing the internal axial walls. For radicular access, the original ProTaper system offers the auxiliary Shaping file, termed SX. The SX file is used in a brushing manner on the outstroke, to preflake the orifice, eliminate triangles of dentin, relocate the coronal most aspect of a canal away from external root concavities, or produce more shape, as desired.

Perhaps the greatest challenge performing endodontic treatment is to find, follow, and predictably secure any given canal to its terminus. Negotiating and securing canals with small-sized manual files requires a mechanical strategy, skilful touch, patience, and desire. A small-sized hand file is initially used to scout, expand, and refine the internal walls of the canal. Once the canal can be manually reproduced, a dedicated mechanical glide path file may be used to expand the working width in preparation for shaping procedures. To clarify, a canal is secured when it is empty and has a confirmed, smooth, and reproducible glide path.

With an estimated working length and in the presence of a viscous chelator, insert a #10 file into the orifice and determine if the file will easily move toward the terminus of the canal. In shorter, wider, and straighter canals, a #10 file can usually be readily carried to the desired working length. Once a #10 file is confirmed loose at length, the glide path may be further enlarged with either a #15 hand file or dedicated mechanical glide path files, such as PathFiles (Dentsply Tulsa Dental Specialties). The glide path just described confirms sufficient existing space is available to initiate mechanical shaping procedures with the PTN X1 file.
In other instances, certain endodontically involved teeth have roots that harbour longer, narrower, and more curved canals (Figure 8a). In these situations, a #10 file will oftentimes not initially go to length. Generally, there is no need to select and use size #06 and/or #08 hand files in an effort to immediately reach the terminus of the canal. Simply and gently work the size #10 hand file, within any region of the canal, until it is completely loose. PTN files can be utilised to shape any region of a canal that has a smooth and reproducible glide path. Regardless of the glide path and shaping sequence, the endgame is to negotiate the entire length of the canal, establish working length, and confirm apical patency (Figure 8b). The canal is secured and a glide path is verified when a #10 file is loose at length and can reproducibly slip, slide, and glide over the apical one-third of the canal.

When any given canal is secured, the access cavity is voluminously flushed with a 6% solution of NaOCl. Shaping can commence, starting with the PTN X1 file. It should be emphasised that PTN files are never utilised with an inward pumping or pecking motion; rather, PTN files are utilised with an outward brushing motion.

Importantly, this method of use will enable any given PTN file to passively move inward, follow the glide path, and progress toward the working length. The X1 file is carried through the access and passively inserted into a pre-flared orifice and secured canal. Before resistance, immediately begin to deliberately brush on the outstroke (Figure 8c). Brushing creates lateral space and enables this file to progress a few millimeters inward. A brushing action serves to improve contact between the file and dentin, especially in canals that exhibit irregular cross-sections or eccentricities off their rounder parts.

Continue with the PTN X1 file through the body of the canal. After every few millimeters of file progression, remove this mechanical shaping file to inspect and clean its flutes. Before reinserting the X1 file, it is critical to irrigate and flush out gross debris, recapitulate with a #10 file to break up residual debris and move it into solution, then re-irrigate to liberate this debris. In one or more passes, continue with the X1 file until the full working length is reached. To promote the mechanical objectives, always irrigate, recapitulate, and then re-irrigate after removing any mechanical shaping file.

Select the PTN X2 file and let it begin to run inward. Before resistance, laterally brush against the dentinal walls, which, in turn will enable the X2 file to passively and progressively advance inward. The X2 file will easily follow the path of the X1 file, progressively shape, and incrementally advance toward length. If this file bogs down and ceases to move inward, remove the file and clean and inspect its flutes. Again, irrigate, recapitulate, and then re-irrigate to promote the mechanical objectives for shaping canals. Continue with the X2 file until the working length is reached; appreciate it may require one or more passes, depending on the length, width, and curvature of any given canal (Figure 8d).

FIGURE 8B. A WORKING IMAGE REVEALS CORONAL DISASSEMBLY, ISOLATION, AND #10 FILES TRAVERSING THROUGH CANALS THAT EXHIBIT CURVATURES AND RECURRENCES.

FIGURE 8D. THIS VIDEO GRAB IMAGE REVEALS A PTN X2 FILE AT LENGTH IN THE MB SYSTEM.

Once the PTN X2 file has reached the working length, it is removed. The shape may be confirmed as finished when the apical flutes of this file are visibly loaded with dentin. Alternatively, the size of the foramen may be gauged with a size 25/02 NiTi hand file. When the size #25 hand file is snug at length, the shape is finished. If the size 25/02 hand file is loose at length, it simply means the foramen is larger than 0.25mm. In this instance, the foramen may be gauged with a size 30/02 NiTi hand file.

If the size #30 hand file is snug at length, the shape is done. However, if the size #30 hand file is short of the working length, proceed to the PTN X3 file, following the exact method just described for the PTN X1 and X2 files.

The vast majority of canals will be optimally shaped after using either the PTN X2 or X3 files (Figure 8e). The PTN X4 and X5 files are primarily used to prepare and finish larger diameter canals. When the apical foramen is determined to be larger than a PTN 50/06 X5 file, recognise other shaping methods may be utilised to finish these larger, typically less curved, and more straightforward canals. What is important is to appreciate that meticulously secured canals promote shaping, 3-D cleaning, and filling root canals systems (Figure 8f).
between martensite and austenite. It should be appreciated that the best transition point is dependent on the cross-section of the file. Research has shown that M-wire, a metallurgically improved version of NiTi, reduces cyclic fatigue by 400% when comparing files of the same D0 diameter, cross-section, and taper.17 This 3rd generational advancement is a strategic improvement to the overall clinical safety and performance of the PTN rotary file system.

The third design feature of PTN is related to its offset cross-sectional design. There are 3 major advantages when a continuously rotating file is designed so its mass of rotation is offset.13

1. An offset design generates a traveling mechanical wave of motion along the active portion of a file. This swaggers effect serves to minimise the engagement between the file and dentin compared to the action of a fixed tapered file with a centered mass of rotation (Figure 9). Reduced engagement limits undesirable taper lock, the screw effect, and the torque on any given file.

2. A file with an offset design affords more cross-sectional space for enhanced cutting, loading, and augering debris out of a canal compared to a file with a centered mass and axis of rotation (Figure 9). Many instruments break as a result of excessive intrabrade debris packed between the cutting flutes over the active portion of a file. Importantly, an offset file design decreases the probability for laterally compacting debris and blocking root canal system anatomy (Figure 6).

3. A shaping file with an offset mass of rotation will generate a mechanical wave of motion analogous to the oscillation noted along a sinusoidal wave (Figure 10). As a result of this design, any given PTN file can cut a bigger envelope of motion compared to a similarly-sized file with a symmetrical mass and axis of rotation (Figure 6). The clinical advantage of this is a smaller-sized and more flexible PTN file can cut the same-size preparation as a larger and stiffer file with a centered mass and axis of rotation (Figure 9).

Discussion
From a clinical standpoint, the PTN rotary system is a convergence of the most proven and successful generational designs from the past, coupled with the most recent advances in critical path technology. This brief discussion will describe how design influences performance.

The most successful generational design of the past is the mechanical concept of utilising a progressively percentage tapered design on a single file. The patented protected ProTaper Universal NiTi rotary file system utilises both an increasing or decreasing percentage tapered design on a single file. This design feature serves to minimise the contact between a file and dentin, which decreases dangerous taper lock and the screw effect, while increasing efficiency.6 Compared to a similarly-sized fixed tapered file, a decreasing percentage tapered file design, strategically improves flexibility, limits shaping in the body of the canal, and conserves coronal two-thirds dentin. Taking advantage of this mechanical design, PTN also utilises progressive tapers on a single file. This design has contributed to the ProTaper system becoming the #1 selling file in the world, the #1 file choice of endodontists, and the #1 system taught in international dental schools to undergraduate students.16

Another critical design feature that is intended to benefit certain brand lines of mechanical shaping files is metallurgy. Although NiTi files have been shown to be 2-3 times more flexible than same-sized SS files, additional metallurgical benefits have been identified using heat treatment. R&D has focused on heating and cooling traditional NiTi, either pre- or post-machining. Heat treatment serves to create a more optimal phase transition point.
References

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Dr. John West, DDS, MSD
As the founder and director of the Center for Endodontics, Dr. West continues to be recognised as one of the premier educators in clinical and interdisciplinary endodontics. John West received his DDS from the University of Washington in 1971 where he is an Affiliate Associate Professor. He then received his MSD in endodontics at Boston University Henry M. Goldman School of Dental Medicine in 1975 where he is a clinical instructor and has been awarded the Distinguished Alumni Award. Dr. West has presented unmatched endodontic continuing education in North America, South America, and Europe while maintaining a private practice in Tacoma, Washington. Dr. West’s memberships include: 2009 president and fellow of the American Academy of Esthetic Dentistry and 2010 president of the Academy of Microscope Enhanced Dentistry, the Northwest Network for Dental Excellence, and the International College of Dentists. He is a 2010 consultant for the ADA’s prestigious ADA Board of Trustees where he serves as a consultant to the ADA Council on Dental Practice.
Time Required to Remove GuttaCore™ Thermofil® Plus and Thermoplasticized Gutta-percha from Moderately Curved Root Canals with ProTaper® Files

By Robert T. Beasley, DMD, Anne E. Williamson, DDS, MS, Bruce C. Justman, DDS, Fang Qian, PhD
Department of Endodontics, University of Iowa, Iowa City, Iowa

Study objective

To evaluate the time required to re-treat GuttaCore, Thermafil Plus and traditional gutta-percha obturations in moderately curved canals with ProTaper Universal Retreatment and Finishing files.

Study design

Canal preparation:
70 mesial roots of mandibular molars without previous endodontic treatment were prepared to ISO size 30 with 0.04 taper and divided in 3 groups:
Group 1: Warm vertical obturation (n=20)
Group 2: Thermafil Plus (n=20)
Group 3: GuttaCore (n=20)
Control (n=10)

Canal obturation:
Group 1: canal coating with AH Plus® sealer followed by obturation using a continuous-wave technique of gutta-percha compaction
Group 2: canal coating with AH Plus sealer followed by obturation with Thermafil Plus following manufacturer instructions
Group 3: canal coating with AH Plus sealer followed by obturation with GuttaCore following manufacturer instructions

Retreatment:
Instrumentation in a crown-down fashion with ProTaper Retreatment files D1, D2, D3 and ProTaper Universal F3

Results

Significantly quicker time for reaching working length $T_1$ and for filling material removal $T_2$ in GuttaCore Group.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Mean Curvature (mm³)</th>
<th>File unwinding</th>
<th>File separation</th>
</tr>
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<tbody>
<tr>
<td>Warm vertical</td>
<td>24.2± 7.1</td>
<td>3 (D3)</td>
<td></td>
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<tr>
<td>Thermafil</td>
<td>23.0± 6.2</td>
<td>4 (D3)</td>
<td>3 (D3)</td>
</tr>
<tr>
<td>GuttaCore</td>
<td>24.2± 6.2</td>
<td>2 (D3)</td>
<td></td>
</tr>
</tbody>
</table>


Conclusion

- GuttaCore obturation was significantly quicker to remove than Thermafil Plus or thermoplasticized gutta-percha ($P < .05$).
- GuttaCore retreatment is respectively 22.0% and 33.3% time saving compared to thermoplasticized gutta-percha and Thermafil Plus.
- GuttaCore retreatment did not induce file separation or significant risk of file unwinding.
gutta•core™
crosslinked gutta-percha core obturator

- superior 3D fills
- ease of retreatment
- post space simplified

www.dentsplymea.com
Clinical Success with Simple Restorations

The performance of restorations made with SDR® and Ceram·X® mono+ is compared with the performance of restorations made with Ceram·X mono+ only in a clinical study by Professor J. W. V. Van Dijken, Biomaterial Research Group, Umea, and Associate Professor U. Pallesen, Copenhagen. Results after 12 months.

Objectives
Clinical evaluation of the bulk fill composite SDR, in Class I and Class II cavities, bonded with the single step self-etching primer Xeno® V+ and covered with the nanoceramic resin composite Ceram·X mono+.

Design
Prospective, longitudinal, controlled, randomised clinical study; method according to ADA Guidelines for Resin Based Composites for Posterior Restorations (2001).

Number of Restorations
200 (76 Class I, 124 Class II) on 84 patients.

Test Materials
Xeno V+, Ceram·X mono+ and SDR.

Control Materials
Xeno V+, Ceram·X mono+.

Method of Evaluation
Clinical examination, rating according to Van Dijken (1986).

Success Criteria
Determination of the effectiveness of the restorations was carried out by assessing the following parameters:
- Secondary caries
- Anatomic form
- Marginal adaptation
- Marginal discoloration
- Surface roughness
- Colour match

These were assessed by using the slightly modified US Public Health Service criteria. For marginal adaptation and discoloration, the involvement of marginal excess was noted. Postoperative sensitivity was also analysed.
Conclusion of Principal Investigator at Baseline
No significant differences were seen between the two experimental restorations for the evaluated variables in the two cavity classes. In some of the restorations the adhesive could be detected as local small white marginal lines.

Conclusion of the Principal Investigator at 12 months
No significant differences were seen between the two experimental restorations for the evaluated variables in the two cavity classes.

Conclusion of the Sponsor at 12 months
No significant difference was seen between the two techniques (SDR-based and conventional non-based). The use of SDR, which involves a simpler and shorter placement technique, seems to have no negative impact on restoration quality.

Both SDR-based and non-SDR based posterior Ceram-X restorations performed well with a survival rate close to 100%.

Indications for SDR® now extended

The range of indications for SDR, the 4mm bulk fill composite material, have been extended.

In addition to use as a base in cavity Class I and II direct restorations and a liner under direct restorative materials, SDR has been approved as a fissure sealant, for core build-ups and small Class I restorations in direct occlusal contact without a separate enamel cap. These extended indications mean that SDR is also ideal for use in paediatric dentistry.

SDR is the original bulk filling material with unique self-levelling properties still unsurpassed when it comes to simplifying the restoration of posterior teeth.
Dyract®: Differentiated for 20 Years

Dyract was first presented to the world at the FDI congress in Göteborg (Sweden) in September 1993. Since then, there has hardly been a material that has been discussed and studied more intensively. The following article demonstrates that the intended application of Dyract reflects a very modern approach in adhesive dentistry.

History
In the late 1980s, DENTSPLY DeTrey, worked on the development of a light-cured material that was to be presented in a paste form, could be used without acid-etching and that would be a meaningful substitution for a glass ionomer. Gordon Blackwell, an experienced development chemist with patents in glass ionomers, resin-based adhesives and acid-modified resins (Engelbrecht, 1989) worked on laying the foundation for a new material: Dyract. The overall aim of Dyract was to combine the best properties from composites such as surface hardness, physical strength, low shrinkage and resistance to wear with the best properties of glass ionomers such as the release of fluoride ions and low technique tolerance. The brand name was created by Rolf Käse and was developed to reflect how the specific composition of Dyract enables the curing of the material to take place in two reactions (“dy”) and (“ract”).

When Dyract was first developed, it was used together with Dyract PSA (primer, sealer, adhesive) for the pre-treatment of the cavity. Today, the etching of dentin with phosphoric acid and the application of an adhesive is preferred as standard clinical practice. The ability to achieve reliable adhesion through the simple application of a bond and subsequent light curing has been a large contributor to the success of Dyract. Another critical success factor for Dyract was the expansion of indications to include the restoration of deciduous teeth – this meant that there was finally a generally accepted alternative to the conventional amalgam which had been the standard in paediatric dentistry (Kramer et al., 2007). In 1997 Dyract was indicated for restoration placement under occlusal load in posterior teeth. To date, approximately 250 million Dyract restorations have been placed worldwide.

Features of Dyract:
Special Chemical Properties:
By integrating acid groups into polymerisable resins (Blackwell, 1993) and combining with basic glass ionomer fillers, Dyract behaves like a composite resin during light-curing – the resins immediately form a stable network by way of a free-radical polymerisation. This network also chemically binds the partially silanised fillers (Figure 1).

As the paste formulation of Dyract doesn’t contain water, no acid-base reaction can take place between the acidic groups and the basic glass ionomer fillers. This means, unlike conventional glass ionomers, Dyract can only be set through light curing. The acid-base reaction sets in only after water is absorbed. Similarly to glass ionomers, when the acid-based reaction does set in, fluoride is released — almost as a by-product of the ionic reaction (Figure 2). The initial fluoride release of Dyract is not as high as traditional glass ionomers. However, long-term testing at the University of Copenhagen demonstrates that the level of fluoride that is released by Dyract after one year is comparable to a conventional glass ionomer (Asmussen et al., 2002).

Caries Protective Effect
Many laboratory studies have shown that the fluoride release from Dyract has an inhibitory effect on the development of carious lesions (Wiegand et al., 2007). During an in-situ study at the University of Göttingen, two groups of subjects were required to wear a removable appliance that simulated proximal contacts between intact enamel and a restorative material; either Dyract, or the composite Spectrum® TPH3® (Figure 3). A caries protective effect was demonstrated for the Dyract group and was significantly higher than that of the Spectrum TPH3 group, even though a fluoride toothpaste solution was applied twice daily to all specimens (Lennon et al., 2007).
Strength Comparable to Composites

Laboratory studies at the Universities of Marburg and Erlangen have demonstrated that Dyract has a marginal quality (Figure 4) that is comparable to conventional composites (Frankenberger, 2013). Further studies testing mechanical properties such as flexural strength (Figure 5) and flexural fatigue (Figure 6) also demonstrate Dyract to be comparable to conventional restorative composites (Lohbauer, 2013).

10 Year Clinical Data

The University of Munich conducted a study to assess the suitability of Dyract for permanent restorations in the posterior region (Hickel, 2013). Three groups were set up, comparing Dyract/Xeno® III with QuiXfil®/Xeno III and Tetric Ceram/Syntac1 to test annual failure rates. Ten years after placement, 102 of the restorations were examined by independent experts. The annual failure rate in the Dyract/Xeno III group was 1.8%, this was not statistically different from the failure rate of the Tetric Ceram/Syntac group and identical to the failure rate of the QuiXfil/Xeno III group (Figure 7).

Fig. 7. Success rate, failures and annual failure rate (AFR) after 10 years (Manhart et al., 2013)

Outlook

Dyract provides proven mechanical strength comparable to conventional composites, carries protective effect on proximal surfaces (demonstrated in-situ) and is indicated for permanent posterior restorations with buccovestibular dimensions of up to two thirds of intercuspal distance. On this basis, it can be concluded that this filling material is ideal for the initial treatment for carious lesions, not only by restoring the lesion itself with a clinically proven material, but by exerting a prophylactic effect on adjacent proximal surfaces through a continuous release of fluoride.

References

1. Tetric Evo Ceram and Syntac are registered trademarks of Ivoclar Vivadent Limited
2. Filtek Z250 and Filtek Supreme XT are registered trademarks of 3M
3. Venus Diamond is a registered trademark of Heraeus Kulzer


Air Polishing

Educational Objectives:
1. Discuss the indications for use of air polishing
2. Review the science of air polishing including advantages and benefits of using air polishing
3. Implement appropriate air polishing technique
4. Understand maintenance of air polishing systems

Introduction
The concept of air polishing is based on a technology developed by Dr. Robert Black in 1945. Dr. Black invented a device called the Air Dent which used compressed air, water and a highly abrasive powder to eliminate pain from cavity preparation, making anesthesia unnecessary. While the Air Dent presented many problems, the technology became the first step in air polishing devices. Air polishing was first marketed in 1976 and from then forth it became widely available. Air powder polishing is accomplished by the propulsion of abrasive particles through a mixture of compressed air and water through a handpiece nozzle. The handpiece nozzle through which the slurry is propelled is activated with a foot control. The psi produced depends on the type of air powder polisher being used. Air powder polishers are manufactured hand piece units that attach directly to the air/water connector on the dental unit, as separate units, or in combination with an ultrasonic scaler.

Indications for use
Coronal polishing is a cosmetic procedure designed to remove extrinsic stains from the enamel surfaces of the teeth. This can be accomplished by abrasion and erosion of the extrinsic stain. The most common technique for stain removal is rubber cup polishing. This technique uses an abrasive polishing agent and a slowly revolving polishing cup to abrade stain from the tooth surface. Air powder polishing is accomplished by erosion of extrinsic stains by suspended abrasive particles within a moving fluid. Kinetic energy propels the air powder polishing slurry particles against the tooth surface thus removing stain. (Figure 1)

The air-powder polisher is shown to be efficient, safe and effective in removing extrinsic stain and plaque biofilm for tooth surfaces. It is equally effective in decreasing root surface roughness after instrumentation. It is also reported to remove plaque biofilm and staining as effectively as a rubber cup and does so in less time. Patients exhibit extensive staining on root surfaces, specifically on areas of recession and at the cementoenamel junction. Removing those stains with a curet, has shown to have reduced root structure. However, when stain removal is for aesthetic reasons, the air-powder polisher is preferable to the curet. The air-powder polisher removes less root structure than the curet in simulated three month recalls for three years. The stain was also removed more than three times faster with the air-powder polisher. Using the air-powder polisher also creates less discomfort for patients who have dentinal hypersensitivity because the sodium bicarbonate particles embed in the dentinal tubules, lessening dentinal hypersensitivity discomfort almost immediately. In vitro, research has shown that there is little or no disruption of enamel, cementum, and dentin surfaces with air-powder polishing. Other research points out that air-powder polishing can render cementum surfaces uniformly smooth, compared to traditional polishing or the use of curets.

The air-powder polisher can remove subgingival bacteria through the Venturi effect. This occurs when the air-water - powder spray is directed at a 90 degree
angle to the interproximal spaces so that a vacuum is created that extracts tissue fluids, including subgingival bacteria from the subgingival space. The air-powder polisher has been used for debridement of Class V abraded areas before placement of glass ionomer cements. When compared to cleaning the area with a rubber-cup polisher, the air powder polished tooth had less microleakage around the enamel-cement interface. Similar results were noted when using the air-powder polisher before sealant application. It was reported to be superior to rubber-cup polishing in preparing enamel for etching and sealants. Deeper resin penetration into enamel and increased sealant bond strength was also reported in comparison with traditional polishing with pumice and water. In addition, clinicians prefer using the air-powder polisher on orthodontic patients and research has shown that it does not affect the bracket adhesive system.

Types of Powder
The most common type of abrasive particle used with the air-powder polisher is sodium bicarbonate, which is treated to be free-flowing with calcium phosphate and silica. Sodium bicarbonate is a food grade material and each particle is approximately 74 mcm in size. The Mohs hardness number for sodium bicarbonate is 2.5, compared to pumice, which has a Mohs hardness number of 6. Sodium bicarbonate is safe for use on enamel, amalgam, gold, porcelain, implants (titanium), and orthodontic materials. However, should be avoided on all types of composites, glass ionomers, and luting agents (cements). When used on implants, air polishing with sodium bicarbonate, should not be directed subgingivally, thus it is the method of choice for decontamination of implants.

A sodium free powder for air powder polishing is available. (Figure 2. Jet Fresh from DENTSPLY). It was developed for patients who are sodium intolerant. This powder is made of aluminum trihydroxide, which has a Mohs hardness number of 2.5 to 3.5 and a particle range in mesh size from 80 mcm to 325 mcm. Aluminum trihydroxide powder is safe for enamel, however, it is too abrasive for use on other tooth structures and its use should be avoided on all dental materials. While aluminum trihydroxide use does not cause surface disruption to porcelain, the luting agent can be removed causing a compromise in the margin integrity that could quickly lead to decay.

**Patient Assessment**
Due to the various indications and contraindications for use of the air-powder polisher, the patient assessment and treatment planning are critical. Patient assessment includes a thorough health history evaluation to rule out patients on a physician-directed sodium restricted diet and hypertension. However, the amount of sodium bicarbonate ingested during air polishing is not sufficient to cause an increase in blood pressure or blood levels of sodium or alkalosis. Patients that are contraindicated also include those with end-stage renal disease, immunocompromised, communicable infection, Addison’s disease or Cushing’s disease. In addition, patients who have respiratory problems such as chronic obstructive pulmonary disease or any condition that interferes with breathing or swallowing should avoid this treatment. These patients are compromised by the aerosols created by air-powder polishing and they are also vulnerable to the development of pneumonia. Contraindications for using the air-powder polisher also include patients taking potassium, anti-diuretics or steroid therapy which can disrupt the acid/base balance.

Contraindications for use of the air-powder polisher also extends to the hard and soft tissues therefore, the dental history assessment is paramount. Hard tissue that is present with any composite resins, sealants or glass ionomers should be avoided due to susceptibility of surface roughness or pitting. Porcelain margins and margins of all restorations can be altered by extensive exposure of the air-powder polisher which can lead to loss of marginal integrity, surface roughness, staining and pitting. Exposed cementum or dentin are structures that are not as mineralised as enamel therefore more susceptible to abrasion. In addition, patients that present with active periodontal conditions with soft and spongy tissue, the air-powder polisher can be susceptible to air embolism or small blood clots. Lastly, pediatric patients with deciduous teeth or newly erupted permanent teeth are contraindicated.

**Patient Preparation**
It is with utmost importance that before using the air-powder polisher, the clinician must prepare both themselves and the patient. Patient preparation would include a thorough explanation of the procedure, review of medical history and taking of blood pressure. Clinician should place a disposable or plastic drape over patient’s clothing, provide the patient with safety glasses and removal of contact lenses. In addition, position the patient more upright and apply non-petroleum lubricant to the lips to protect from the abrasive spray which can dry the lips. When the clinician performs air-powder polishing, aerosols of microorganisms that contaminate surfaces several feet from the operative site have been reported. Therefore, instructing the patient to use an antimicrobial preprocedural rinse, such as 0.12% chlorhexidine, reduces bacterial contamination of aerosols.

**Air-powder polishing unit and operator preparation**
The clinician should be appropriately protected when performing air-powder polishing. The use of standard precautions, which include wearing fluid resistant protective apparel, face shield or protective safety glasses with side shield, gloves and well-fitting mask with high filtration capabilities. In addition, due to the high aerosols contamination the use of a high-speed evacuation system is recommended. Clinicians should always follow the manufacturer’s directions for use specific to the air-polishing unit being used.

Unit preparation includes obtaining all the necessary equipment such as the air-powder polishing unit and abrasive powder according to patient selection. The unit and hand piece nozzle is prepared according to manufacturer’s instructions and the powder compartment filled with the appropriate product for the device being used. (Figure 3).
The unit should be turned on for at least 15 seconds to eliminate residual powder or moisture in the lines. Also, water lines need to be flushed before use, according to the recommendations of the Center for Disease Control and Prevention. When filling the chamber with abrasive powder, the unit must be turned off and filled with powder to the top of the center tube. The clinician can place their finger over the tube in the middle of the chamber to prevent powder from blocking the air line. Next, the clinician needs to use the control on top of the powder chamber cap to adjust the powder flow according to patient’s needs. For patients with heavy stains the control knob should be turned to H for heavy powder flow, approximately 12 o’clock position. For patients with light staining, the control knob should be set at L for reduced powder flow which is approximately the 6 o’clock position (Figure 4).

An aerosol-reduction device that connects the saliva ejector or high speed evacuation system to the air-polisher hand piece has been shown to be effective in controlling and reducing air-powder aerosols, thus decreasing the potential for disease transmission. This device which is referred to as an Aerosol Reduction device, reduces or eliminates the visible aerosols normally produced during air-powder polishing. Additionally, the Aerosol Reduction device (Figure 5) eliminates the use of exact angulations with cup/nozzle, use of gauze, hand cupping and patient positioning. Other advantages to the Aerosol Reduction device are that it minimises the possibility of tooth abrasion since the cup is placed on the tooth as with traditional polishing techniques. When using the Aerosol Reduction device the clinician must follow manufacturer’s instructions on assembling and disassembling. This aerosol reduction device contains two parts, a disposable cup that attaches to the air powder polisher nozzle and a clear tube extension which is attached to the saliva ejector or HVE.

Disease Control and Prevention. When filling the chamber with abrasive powder, the unit must be turned off and filled with powder to the top of the center tube. The clinician can place their finger over the tube in the middle of the chamber to prevent powder from blocking the air line. Next, the clinician needs to use the control on top of the powder chamber cap to adjust the powder flow according to patient’s needs. For patients with heavy stains the control knob should be turned to H for heavy powder flow, approximately 12 o’clock position. For patients with light staining, the control knob should be set at L for reduced powder flow which is approximately the 6 o’clock position (Figure 4).

Clinical Technique
There is a universal air-powder polishing technique that can be used with all types of systems, however manufacturers may have different instructions for their equipment. The recommended technique prevents undue aerosols from deflecting back to the clinician or being directed into the patient soft tissues. The use of high speed evacuation or Aerosol Reduction device is the most efficient control of the aerosol spray. While positioning of the patient and operator are basically unchanged, direct vision and access become fundamentally important when the polisher is active. Positioning the patient slightly upright at 45 degrees with the patient’s head toward the operator and reclining to treat maxillary lingual surfaces provide a better field of vision and increase patient comfort. Placing moistened 2” x 2” gauze square over the tongue or on the patient’s lip near the work area will help reduce burning and stinging experienced by some patients. The rheostat has two compressions levels; full compression releases the aerosol powder-abrasive from the tip and halfway compression produces a stream of water for rinsing and cleaning. It is recommended that the clinician check the amount of water and powder coming from the unit before activation in patients’ mouth so to test the sensitivity of the alternating cycles and to confirm the powder to water ratio.

The clinician should establish and maintain a systemic pattern when using the air-powder polisher. The nozzle tip should be an appropriate distance from the tooth surface which is approximately 3mm to 4mm. Holding the nozzle further away from the tooth surface is not recommended because it minimises the abrasive action and increases aerosol production. Cupping the lip with the index finger and thumb to pool water in vestibule minimises aerosol and eases evacuation. The nozzle tip should also be angled diagonally so that the spray is directed toward the middle third of the tooth. The clinician will use a constant circular motion, sweeping or paint-brush motion from interproximal to interproximal. In addition, a systematic approach by polishing one or two teeth at a time will ensure that all tooth surfaces are adequately polished. Alternate cycles of full-compression powder-spray and half-compression rinse every two or three teeth will increase efficiency and patient comfort. The clinician must polish each tooth for approximately 1 to 2 seconds and should avoid loss of tooth surface by subj ecting the tooth to no more than ten seconds of air polis h slurry. Root surfaces should also be avoided or less time spent because they abrade more rapidly than enamel.

The DENTSPLY Cavitron Jet Plus has a Tap-On™ technology (Figure 6) which eliminates the need for the clinician to pump the pedal by automatically cycling between rinse and polish. This Tap-On™ technology works by way of tapping the foot pedal once which will enable an automatic air polishing/rinse cycle that lasts for approximately one minute and tapping the pedal a second time disables the automatic air polishing/rinse cycle. The DENTSPLY Cavitron Jet Plus™ device autocycles work via short, medium and long settings (Figure 7) and are timed cycles of one minute that automatically alternate between air powder polishing and rinse (water only) without having to use the foot pedal to alternate between the two.
A single tap to the foot pedal starts each one minute cycle and each cycle begins with a 2 to 3 second stream of water. The “short” autocycle is a .75 second of air-powder polishing followed by a 1.25 seconds rinse; the “medium” autocycle is a 2 second air-powder polishing followed by a 1 second rinse; the “long” autocycle is a 3 second air-powder polishing followed by a 2 second rinse. The “manual” cycle setting uses the Tap On™ foot technology control to manually alternate between air-powder polishing and rinse.

Completion of air-polishing procedure
At completion of the air-polishing procedure the clinician should rinse the teeth thoroughly, floss all interproximal surfaces and inspect the teeth for any remaining stain. Thorough rinsing is essential after air powder polishing because of the basic nature of the sodium bicarbonate. If stain is still present, reinstrumentation and or use of the air powder polisher may be indicated. Any debris should be wiped off the patient’s face with a moist towel and offer additional lip balm. The Aerosol Reduction device should be disposed of and the nozzle should be cleaned with a wire-cleaning tool to prevent clogging. Nozzle tips must be autoclaved after each use and the entire unit should be disinfected with an Environmental Protection Agency approved disinfectant. Using a disposable barrier will help minimise disinfecting time.

At the end of the day the unit should be turned off, remove powder from chamber and discard the unused powder to prevent clogging of lines. Also, keep powder chamber and air lines free of moisture, which can cause the system to fail. The clinician will then remove any residual powder from the chamber with a HVE and activate the unit for approximately fifteen seconds to clear any powder remaining in the chamber.

Conclusion
Therapeutic polishing is the removal of toxins from the unexposed root surfaces, which results in a decrease in disease parameters. Polishing root surfaces is possible with both the rubber-cup or air-powder polisher, however the rationale for selecting the air-powder polisher is for its effectiveness and efficacy. The clinician should follow the precautions and considerations presented when polishing for therapeutic benefits with the air-powder polisher. The clinician should be aware to direct the air-powder spray against the tooth surface, not the exposed soft tissues. Most importantly the clinician must consider all options; aesthetic, therapeutic, and patient goals, when designing a treatment plan that meets the patient specific needs.

References:
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