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Glide path and root canal preparation in reciprocating motion: root canal treatment of a mandibular premolar with complex root canal morphology using R-Pilot and Reciproc Blue

Introduction:
The mechanical preparation of a root canal system is indispensable for a successful endodontic treatment outcome. Teeth with complex root canal morphologies, in particular, represent a special challenge; the practitioner should possess thorough knowledge of root canal morphology, as well as, be able to employ suitable endodontic instruments. The development of new nickel titanium alloys, through modifications made to their material properties, now permits the production of endodontic instruments which can meet even the highest requirements for root canal preparation. In this manner, the incidence of preparation errors and instrument fractures can be considerably decreased.

Materials and Methods:
A female patient with acute dental pain, originating from tooth 34, presented herself to the Department of Periodontology and Conservative Dentistry, a part of the University Clinic Münster. Following a detailed examination, root canal treatment on the tooth was performed. In this case report, R-Pilot and Reciproc Blue instruments (both VDW, Munich, Germany) were employed to treat a first mandibular premolar with a Vertucci type III canal configuration.

Results:
In the present case, in spite of complex root canal morphology, a sufficient and satisfactory root canal treatment outcome was achieved. This was realized through the use of R-Pilot files to establish an initial glide path and the subsequent use of Reciproc Blue files for further canal preparation.

Conclusion:
Knowledge of possible root canal system configurations and identification of such cases in daily clinical practice is a prerequisite for successful root canal therapy. Furthermore, a case-specific selection of endodontic instruments should be performed in order to prevent preparation errors and instrument fractures. It is also important to point out that a preceding glide path preparation helps to facilitate an easier and safer canal preparation and should therefore be considered as obligatory.

Keywords: Blue-Wire; glide path; M-Wire; Reciproc-Blue; R-Pilot

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Introduction

The ultimate goal of root canal therapy is the long-term preservation of the tooth; this is achieved by removing the irreversibly damaged pulp tissue as well as the preparation, disinfection, and subsequent three-dimensional obturation of the root canal system. An essential step in performing root canal therapy represents the mechanical preparation of the root canal system. In order to provide sufficient space for chemical disinfection, the original root canal course should be maintained by means of even and circumferential removal of root canal wall dentin. Also, the shape of the prepared root canals should ease the three-dimensional obturation [21]. Although there exist numerous root canal preparation techniques, which all have the scope of ensuring optimal root canal shaping, preparation errors remain a frequent problem in daily practice. For the preparation of more curved root canals, the selection of suitable instruments plays a critical role.

Enormous progress has been made in the field of rotary (or mechanical) root canal preparation since the development of nickel-titanium (NiTi) alloy in the 1960s and its introduction in endodontics [8]. Despite the fact that conventional NiTi instruments have significantly increased flexibility in comparison to conventional stainless steel instruments [28], instrument fractures and preparation defects, such as ledge formation or canal perforation, continue to be a problem in clinical practice, especially when preparing curved root canals [19]. For this reason, various patented thermomechanical processing methods have been developed for the purpose of optimizing the mechanical properties of NiTi root canal instruments. Modifications made to the NiTi alloy have aimed to further improve the flexibility of the NiTi instruments and to reduce their risk of fracture, without adversely affecting their cutting efficiency [32]. Therefore, a number of modified NiTi alloys such as M-Wire, CM-Wire, Gold- and Blue-Wire or MaxWire have been developed, each of which displays different material properties [32].

Besides the effort made to facilitate root canal preparation through the optimization of endodontic instruments, there exist additional measures related to the exposure and instrumentation of root canals, which could minimize preparation errors and contribute to the avoidance of iatrogenic damage to the root canal system. One such measure is represented by the need to perform preflaring before initial root canal instrumentation; dentin overhangs, which hinder the straight-line insertion of the endodontic instruments into the root canal, must be removed before actual canal preparation.

Another important aspect worth consideration, in order to avoid preparation errors, is the preparation of a glide path from the canal entrance to the physiological terminus [30]. This is especially recommended when narrow and/or strongly curved canals are present, and mostly before the use of mechanically operated preparation instruments. In this respect, stainless steel manual instruments as well as mechanically operated NiTi instruments could be employed. Stainless steel hand instruments (so-called pilot instruments) allow tactile control, may be pre-curved, have a low fracture risk, and permit inferences to be made about existing canal curvatures. The creation of a glide path with mechanical glide path instruments is described as being time-saving and safe [15]. According to some studies, mechanical glide path preparation is better able to preserve the original canal course in comparison to manual stainless steel instruments [1]. Moreover, subsequent debridement of the root canal in the periapical tissue after mechanical glide path preparation should be performed in order to reduce the risk of postoperative discomfort [16, 22]. The created path during glide path preparation allows for improved centering of succeeding instruments, thus reducing unwanted preparation errors such as root canal displacement, ledge formation and instrument fracture [17].

In this case report, a mandibular premolar with Type III (1–2–1) root canal configuration according to Vertucci (Fig. 1) was prepared with R-Pilot and Reciproc Blue files (both VDW, Munich, Germany).

Reciprocating motion

Ongoing metallurgical development of conventional NiTi alloys has enabled the introduction of reciprocating root canal instruments. To date, there are numerous reciprocating endodontic instruments available on the market; these include Reciproc, Reciproc Blue, R-Pilot (all VDW, Munich, Germany), WaveOne, WaveOne Gold, WaveOne Gold Glider (all Dentsply Maillefer, Ballaigues, Switzerland), R6 ReziFlow (Komet Dental, Lemgo, Germany) and Sendoline (Sendoline, Täby, Sweden).

The reciprocating movement pattern is based on the manual balanced-force technique; preparation of the root canal occurs with small 1/4 rotations clockwise or counterclockwise. This concept in the sequence of motion has been transferred to mechanical NiTi instruments, but with modifications. In contrast to the balanced-force technique, tooth substance (dentin) removal by means of the working movement occurs in a counterclockwise direction. As part of the reciprocal movement pattern, the instrument is first rotated in the cutting direction (counterclockwise). Subsequently, a reverse movement in the opposite direction (clockwise) takes place, therefore allowing the instrument to be disengaged from dentin. In this manner, jamming of the instrument in the canal is prevented. The movement in the cutting direction is greater than in the return movement, thus fostering a progressive advancement of the instrument in an apical direction with each movement cycle. Counterclockwise rotation of the reciprocating instrument is greater (150°) than clockwise rotation (30°), thus allowing a complete turn (360°) to occur after about three to four reciprocating movements [12]. Moreover, the cutting angles of the instruments are predetermined so that they cannot exceed their elastic limits. This allows a considerable reduction in the risk of torsional fracture. Also, noteworthy is that it is necessary to use a special motor with a corresponding program of reciprocating movement in order to carry out the pro-

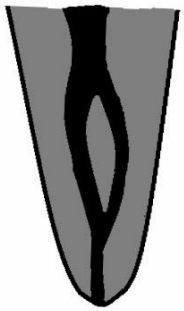

Figure 1 Schematic drawing of the Vertucci Class III root canal configuration (1–2–1)

Figure 2 Above Reciproc Blue, below R-Pilot instruments

cedure in accordance to the manufacturer's recommendations. This applies to the use of the R-Pilot file as well.

Glide path – R-Pilot instruments

The R-Pilot instrument (VDW) is a machine-driven file which prepares a glide path in the root canal system prior to preparation of the canal in reciprocating mode (Fig. 2). Before its use, it is recommended that a manual glide path up to ISO size 08 is created. The R-Pilot instrument has a non-cutting tip with a diameter of 12.5/100 mm, a taper of 4 %, a S-shaped cross-section, and is composed of a modified NiTi alloy named M-Wire. In the production of M-Wire NiTi alloy, 55.8 % nickel and 44.2 % titanium is used [32]. The patented thermomechanical machining process results in a superior alloy, which is more flexible and more resistant to fatigue-induced fractures than conventional NiTi alloy [18, 5]. These properties are attributed to the altered phase composition of the material when compared to conventional NiTi.

Reciproc Blue instruments

The Reciproc Blue instruments are the result of continued development of Reciproc instruments (Fig. 2). Like their predecessor, they constitute a single-file system. The Reciproc Blue files are available in sizes 25/.08, 40/.06, 50/.05, have a regressive taper, a S-shaped cross section with 2 cutting edges, and a non-cutting instrument tip. Only in their metallurgical properties alone do the Reciproc Blue instruments differ from the other Reciproc instruments. Whereas Reciproc is made from M-Wire, Reciproc Blue is made from Blue-Wire. This material is a modified NiTi alloy produced by a special heat treatment, which ensues after the instruments have first been ground according to the proven method. This heating process alters the phase composition of the alloy [32]. Interestingly, owing to the heating, an accompanying color change of the instrument also takes place. It is speculated that heating results in oxide layer formation on the instrument surface, thus endowing it with a blue color. To date, however, there are no studies which have investigated the precise metallurgical phase composition of Blue-Wire. It is assumed that the martensite fraction in the alloy is higher than that in M-wire alloy; this may explain why Blue-Wire heat-treated instruments show significantly higher flexibility and increased resistance to cyclic bending fatigue [7]. Instruments made of this material can be easily pre-curved and display a memory-effect, meaning that they have the ability to return to their initial shape. These properties should therefore warrant an accurately shaped preparation of complex channel configurations.

Case representation

Anamnesis and diagnosis

Due to acute pain originating from tooth 34, a 56-year-old female patient presented herself to the Polyclinic for Periodontics and Conservative Dentistry, part of the University Hospital of Münster. Apart from medicated hypothyroidism and long-term tobacco consumption, the general medical history showed no abnormalities.

Clinical and radiological examination (Fig. 3) revealed a profound carious lesion distally on tooth 34; percussion was negative and pulp vitality was significantly delayed. A mental nerve block was performed using Septanest anesthetic with epinephrine 1: 200,000 (Septodont, Niederkassel, Germany). The pulp tissue was exposed during excavation of the carious dentin, thus producing profuse, uncontrolled bleeding. Subsequently, complete excavation was performed and a pre-endodontic construction was made. In order to provide pain relief, Ledermix (Riemser, Greifswald, Germany) was applied on the crown pulp and the cavity was first temporarily closed with Ketac Fil Plus (3M Germany, Seefeld, Germany).

Trepanation, access cavity, canal exposure

Afterwards, the patient was referred to the Department of Endodontics, a part of the Polyclinic for Periodontology and Conservative Dentistry. A periapical radiograph using the paralleling technique was made prior to further treatment (Fig. 4). The root canal configuration was identified as being type III (1–2–1) according to Vertucci (Fig. 1). A mental nerve block anesthesia was administered at the beginning of treatment using Septanest with epinephrine 1:200,000 (Septodont). After that, a rubber dam was applied in order to ensure compliance with aseptic work-

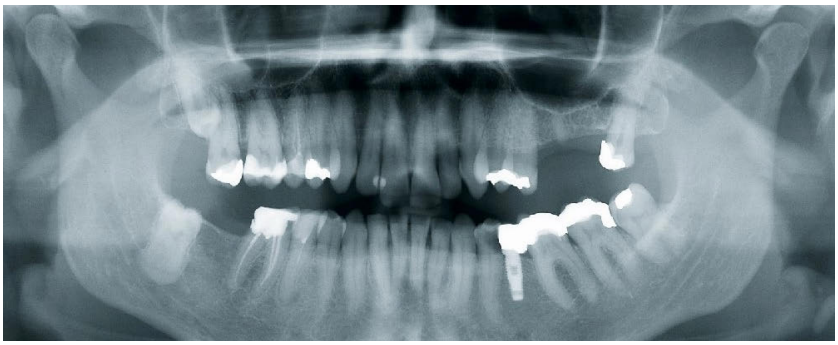

Figure 3 Preoperative panoramic radiograph. Tooth 34 shows an extensive carious lesion distally.

Figure 4 The radiograph of tooth 34 suggests a Vertucci typ III canal configuration

ing conditions throughout the duration of therapy. Trepanation of the tooth was performed and a dental microscope was utilized during the whole course of treatment. With the purpose of creating straight-line access for the instrumentation of the canals, the coronal portion of the canal was extended up to the point of canal branching using the Endo-Explorer Set (Komet Dental, Lemgo, Germany; Fig. 5). This allowed for the selective removal of dentin overhangs. The root canals could be localized in the mesio-distal position and were instrumented using C-pilot hand files (VDW) of ISO sizes 08 and 10. Using pre-curved instruments, patency could be achieved via the mesial canal. The distal canal ended 3 mm short of the apex; this was interpreted as indicating the confluence of this canal at an obtuse angle into the mesial canal, and was therefore verified by introducing instruments into both canals. Using an apex locator, a working length of 23 mm was established for the mesial canal. Meanwhile, the distal canal opened into the mesial canal at 20 mm.

Chemomechanical debridement

After determining the working length, the R-Pilot instrument (12.5/.04) was used to mechanically prepare the glide path. The Reciproc Blue instrument (size R25) was used subsequently to prepare the canals. During the procedure, each canal was rinsed with 5 ml NaOCl (2.5 %) and the instrument was moved slowly towards and away from the apex using very slight pressure. The amplitude of the up and down movements was not more than 3 mm. After 3 picks, the file was removed from the canal and cleaned in Clean-Stan. Each time, the root canals were also rinsed. Between preparation steps, a C-Pilot file of ISO size 10 was used for recapitulate the canals and to check for apical continuity. This measure was taken to prevent apical blockage. Upon completion of the preparation, the working lengths were rechecked by means of an apex locator. Then, the canals were rinsed with 10 ml each of citric acid (17 %) as well as 10 ml NaOCl (2.5 %). Ultrasonic irrigation of sodium hypochlorite was performed in each canal based on the EDDY approach (VDW) for 3 x 20 seconds each. In order to achieve this, a polyamide tip driven by an Airscaler at a high frequency of up to 6,000 Hz was employed. The created oscillations trigger cavitation and swirl the rinsing fluids, thereby achieving a significantly improved cleaning performance [25]. To end with, each root canal was rinsed with 5 ml chlorhexidine (2 %) and dried with paper tips.

Guttapercha (R25 Reciproc Blue pens) were adapted to the preparation system so that a noticeable "tug-back" was present. Due to reproducible readings with the apex locator, a master point radiograph was omitted. The thermoplastic obturation was then made using the continuous wave technique by means of the Beefill 2in1 device (VDW). An epoxy resin sealer (2Seal, VDW) was used. At first, the distal canal was filled. The fit of the mesial masterpoint was rechecked in order to obturate the mesial canal. This was done in order to ensure that no bubbles could form in the area of the confluent canals.

The Guttapercha was separated at the branching point of the 2 canals. Then, the coronal third of the root canal was conditioned with dentin adhesion promoter (Optibond FL, Kerr Dental, Rastatt, Germany) and filled with SDR (Dentsply DeTrey, Constance, Germany) up to the level of the cementoenamel junction. The covering filling was made using Estelite Sigma Quick (Tokuyama Dental Germany, Altenberge, Germany). Finally, a radiograph was taken to control the root filling (Fig. 6). The film showed an adequate root canal filling, which appeared homogeneous and edge-tight.

Follow-up Control

After 4 months, the patient presented herself once again for the radiographic control of tooth 34. The patient reported no symptoms on tooth 34. The tooth also remained free of any symptoms upon performing ongoing routine check-ups. The absence of apical periodontitis and the continuity of the periodontal ligament is suggestive of successful root canal treatment (Fig. 7).

Discussion

Root canal treatment of teeth with a Vertucci Class III configuration presents a major challenge. For long-term therapeutic success, it is first and foremost

Figure 5 Endo-Explorer set

critical to recognize that an anatomical variation is present, which occurs in only 4 % of the cases for first mandibular premolars [27]. It also implies that the dentist should be acquainted with the possible variations of root canal morphology. In this manner, deviations from the standard morphology could be detected quicker and more reliably. Furthermore, from a clinical point of view, it is necessary to use an optical magnifying aid in every case. The use of a dental microscope permits detailed exploration of root canal morphology and enhances the viewing conditions needed for correct access cavity preparation. A prerequisite for the instrumentation of root canals is the creation of straight-line access by removal of dentin overhangs, as overhangs could obstruct the view of other possible canal entrances. Moreover, the mandatory diagnostic radiograph, preferably from 2 projection angles, should serve to provide important preoperative hints with respect to root canal morphology. To exemplify this, when analyzing a radiograph, the abrupt disappearance of a large-lumen root canal in the upper or middle third of the root is indicative of a canal bifurcation (Fig. 4).

In this case report, due to the existence of irreversible pulpitis and no signs of apical periodontitis on tooth 34, a one-step root canal treatment was selected. The goal of the applied rinsing protocol was to remove pulp tissue rests and organic components from the smear layer through the use of NaOCl (2.5 %). Additionally, irrigation with citric acid (17 %) was performed in order to remove inorganic components from the smear layer. When used in alternation, these 2 root canal solutions provide clean root canal walls and open dentinal tubules [29]. The final chlorhexidine (2 %) rinse was used to expand the spectrum against particularly problematic germs found in root canals; its usage is, however, controversially debated. From a purely microbiological perspective, a final rinse with chlorhexidine is not considered necessary when performing vital pulpectomy. Nevertheless, since a final rinse with chlorhexidine ensures significantly better wetting of the epoxy resin-based sealer onto the root canal wall following smear layer removal, final irrigation with chlorhexidine was not omitted in the present case [6].

The mechanical glide path preparation with the R-Pilot instrument, followed by the subsequent preparation of the root canals with the Reciproc Blue instrument, achieved a satisfactory treatment result. After the root canal filling was completed, the tooth was temporarily treated with a dentin-adhesive composite filling. In the long-term, a ceramic crown restoration is planned for the tooth. Thus, the remaining tooth hard substance can be conserved and stabilized when having to cope with a daily chewing load.

The case-related selection of suitable root canal instruments represents an essential and relevant step in root canal therapy; this is discussed below. Pertaining to this case, the specific root canal morphology as well as the findings in recent literature were taken into consideration.

Both types of utilized instruments worked using reciprocating motion. Studies show that the reciprocating movement pattern hinders instrument jamming in the root canal, therefore increasing the fracture resistance of NiTi instruments [11]. Furthermore, reciprocating instruments have been reported to have longer lifetimes in comparison to fully rotating instruments [26]. However, whether or not the reciprocating motion leads to increased debris extrusion compared to the fully rotary motion remains controversial; this seems to be dependent on study design among other factors [3, 13].

Since the introduction of Reciproc Blue instruments, several studies have examined if there are differences between them and previous generation Reciproc instuments. When compared to Reciproc M-Wire-NiTi instruments, it has been shown that Reciproc Blue instruments have significantly increased flexibility and resistance to cyclic fatigue owing to their modified alloy composition, [7, 23]. More recent studies have compared how highly curved root canals were shaped by Reciproc Blue and WaveOne Gold, the latter being another reciprocating Gold-Wire-NiTi instrument. For the preparation of root canals with 25°–35° curvatures, neither Reciproc Blue nor WaveOne Gold produced a more correct preparation form than their predecessors made of M-Wire-NiTi (Reciproc and WaveOne) [4]. Topçuoğlu et al. showed that Reciproc Blue was more resistant to cyclic fatigue when compared to WaveOne Gold in canals with root canal curvatures of 60°. On the other hand, for root canals with curvatures of 45°, no significant differences between the 2 instruments were observed [24]. Based on the results from these 2 studies [4, 24], it can be inferred that Reciproc Blue instruments may offer advantages, especially, when preparing highly curved canals.

Although root canal preparation with Reciproc and Reciproc Blue instruments does not usually require previous glide path preparation according to the manufacturer, recent studies suggest that glide path preparation has certain benefits. One study observed that the presence of a glide path resulted in less pronounced apical foramen transportation during processing with Reciproc files [2]. Moreover, preparation-related debris extrusion into the periapical tissue was reduced by prior glide path preparation in curved root canals [22]. According to Pasqualini et al. glide path preparation with rotary NiTi files resulted in less pronounced postoperative complaints compared to manual glide path preparation

Preliminary evidence also suggests that the preparation of a glide path prior to the use of Reciproc Blue instruments improves subsequent root canal preparation in highly curved canals [10]. Owing to glide path preparation, Reciproc Blue instruments are better able to remain properly centered during canal preparation, thus allowing them to follow the original canal course more accurately. The transportation of the apical foramen, the so-called canal displacement, could therefore be largely avoided.

In this case, the R-Pilot instrument was chosen for glide path preparation. According to studies, it has a higher resistance to cyclic fatigue in comparison to other mechanical glide path instruments, such as One G (Micro Mega, Besançon, France), ProGlider, WaveOne Gold Glider (both Dentsply Maillefer) and HyFlex EDM (Coltene, Altstätten, Switzerland) [31, 14].

A possible explanation for the beneficial properties of the R-Pilot instruments may lie in their S-shaped cross-section, which ensures a comparatively small core diameter. As a general rule of thumb, the smaller the cross-sectional diameter of an instrument, the greater its resistance to cyclic fatigue and the greater its flexibility [20]. In this way, R-Pilot instruments are considered safe from a clinical point of view; they possess high fracture resistance as well as facilitate the preparation of a glide path without canal displacements or preparation errors (great flexibility) in the presence of anatomically complex and strongly curved root canals. For the treatment of the case presented here, the R-Pilot and the Reciproc Blue instruments were selected. Certainly, the root canal treatment could have been possible with other instruments. Similar metallurgical and physical properties exist, for example, in the WaveOne Gold Glider (Dentsply Maillefer), which represents an alternative to the R-Pilot instrument. This machine-operated glide path instrument also works using reciprocating motion. It consists of Gold-Wire, which is another type of heat-treated NiTi alloy and has a progressive taper between 2 % and 6 % as well as a diameter of 15/100 mm at the instrument tip. The instrument's cross-section is in the form of a parallelogram. One study has shown that the R-Pilot instrument and the WaveOne Gold Glider are more resistant to cyclic fatigue when compared with various rotary glide path instruments [9]. In a direct comparison with one another, however, the 2 reciprocating glide path instruments showed no significant differences in the aforementioned study. Another alternative to the employed Reciproc Blue instrument is represented by the WaveOne Gold system (Dentsply Maillefer). These instruments are made of Gold-Wire, have the same cross-sectional shape as the WaveOne Gold Glider, and use reciprocating movement [4].

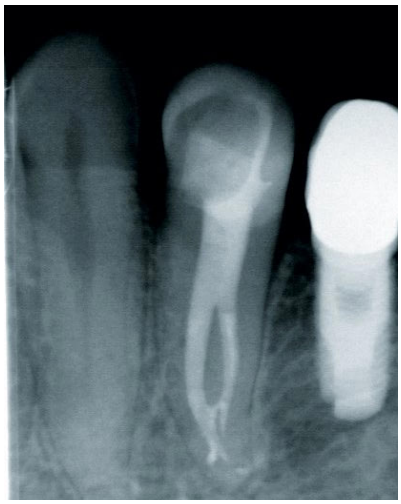

Figure 6 Radiographic control of tooth 34 after root canal obturation

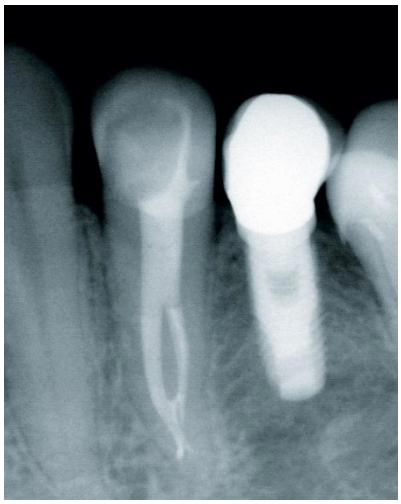

Figure 7 Radiographic follow-up of tooth 34 after 4 months

(Fig. 1–7: N. Vahdat-Pajouh)

Conclusion

The decision-making process for choosing a suitable instrument and its associated working motion depends on a number of factors. A case's particularities are relevant in deciding whether or not a previous glide path preparation is required in order to simplify the preparation of the root canals. Since the principal goal in selecting the appropriate instrument is to provide safe canal preparation while also preserving the original canal shape, special attention should be given to glide path preparation. In summary, it can be generally stated that the use of the R-Pilot instrument is recommended in cases of severely narrowed canals or more complex root canal configurations, which could lead to difficult preparation of the root canals. Despite the benefits of its use, it should be clearly noted that abrupt root canal curvature (large angle of curvature with low radius of curvature) in the apical region is a contraindication for the use of the R-Pilot instrument. In such cases, preparation should be done with pre-curved hand instruments. This also applies to the use of Reciproc Blue instruments. In spite of the manufacturer's claim that glide path preparation is not required in the majority of cases when using Reciproc Blue instruments, the clinical benefits of a glide path preparation should still be carefully considered. One such example is the reduction of postoperative discomfort.

A careful selection of case-related preparation tools and techniques can markedly reduce the risk of preparation errors and instrument fractures in daily clinical practice.

Conflicts of interest:

The authors declare that there is no conflict of interest within the meaning of the guidelines of the International Committee of Medical Journal Editors.

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