Acta Stomatologica Naissi jun/June 2004, vol. 20, broj/number 46; str./p 261-274

PREGLEDNI RAD
REVIEW ARTICLE

MAŠINSKA OBRADA KANALA KORENA SA ENDOflash SISTEMOM – PREGLED

MECHANICAL ROOT CANAL PREPARATION WITH THE ENDOflash SYSTEM – A REVIEW

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Kratak sadržaj

ENDOflash sistem predstavlja rotirajući nasadni instrument za mašinsku obradu kanala korena, putem kontrolisane rotirajuće sile, uz pomoć iglica od nerđajućeg čelika ili NiTi-ijuma. Iako se sistem primenjuje već nekoliko godina, dostupno je samo nekolio studija. Vrednovani su rezultati iz literature koji upoređuju različite sisteme a tiču se ispravljanja kanala korena, prodora ka vrhu, čišćenja kanala i utrošenog vremena. Ni u jednoj od citiranih studija nije se pojavila fraktura ENDOflash iglica od nerđajućeg čelika a ni ENDOflash NiTi iglica. Uzimajući u obzir ispravljanje i prodor kroz iskrivljene kanale korenova, čini se da upotreba iglica od nerđajućeg čelika nije sasvim idealna. U poređenju sa ostalim rotirajućim NiTi sistemima ENDOflash NiTi iglice nude podjednake rezultate u toku pripreme iskrivljenih kanala korena. Što se tiče čistoće kanala korena objavljeni su kontradiktorni rezultati. Utrošeno vreme u pripremi kanala korena je isto ili čak kraće u poređenju sa drugim sistemima, ako se upotrebljavaju NiTi iglice.

Zaključak: ENDOflash kolenjak, korišćen zajedno sa NiTi iglicama, siguran je sistem za mehaničku pripremu kanala korena. ENDOflash iglice od nerđajućeg čelika ne bi trebalo da se koriste zbog njihove nezadovoljavajuće sposobnosti prilagođavanja obliku kanala.

Ključne reči: *ENDOflash, mašinska obrada kanala korena, pregled*

Abstract

The ENDOflash system is a rotating handpiece for mechanical torque controlled root canal preparation with stainless steel or NiTi files. Although the system is on the marked for several years only a few studies are available. The results of the literature comparing different systems concerning root canal straightening, apical transportation, canal cleanliness and time consumption were evaluated.

In none of the cited studies a fracture of an ENDOflash stainless steel or an ENDOflash NiTi file occurred. Regarding straightening and transportation of curved canals the use of stainless steel files seems to be less than ideal. Compared to other rotary NiTi systems ENDOflash NiTi files offer equal results in preparing curved root canals. With regard to root canal cleanliness contradictory results are published. The time consumption in root canal preparation is said to be equal or even shorter compared to other systems if NiTi files are used.

Conclusion: The ENDOflash handpiece used with ENDOflash NiTi files is a safe system for mechanically root canal preparation. ENDOflash stainless steel files should not be used due to their unsatisfactory shaping ability.

Key words: *ENDOflash, mechanical root canal preparation, review*

Uvod

Glavna prednost endodontskih instrumenata proizvednih od legura nikl-titanijuma (NiTi) je njihova visoka fleksibilnost koja poboljšava njihovu sposobnost da čiste i oblikuju čak i preterano iskrivljene kanale korena. Mana je u poređenju sa instrumentima od nerđajućeg čelika – viša stopa frakture. Zbog ovog relativno povećanog rizika frakture u toku mašinske pripreme kanala korena sa NiTi instrumentima nova automatizovana sredstva i/ili kolenjaci su napravljeni da bi se poboljšala sigurnost rada (izbegavajući lomljenje instrumenata). Ovi automatizovani uređaji ili kolenjaci poseduju posebnu kontrolu rotirajuće sile. Rotacija instrumenta u korenu kanala se ili automatski zaustavlja ili se pravac rotacije okreće unazad čim rotirajuća sila dostigne pripisani limit u toku pripreme kanala korena. Instrument se ne rotira dublje u kanal korena pri čemu se izbegava fraktura instrumenta. Princip kontrole rotirajuće sile se bazira na činjenici da je izdržljivost rotirajućeg instrumenta povećana, čim se instrument zaglavi u kanalu korena ili kada je trenje veliko.[1,2] Do lomljenja instrumenta će doći ukoliko rotirajuća sila prevazilazi vrednost karakterističnu za sve instrumente. Ukoliko se rotacija instrumenta zaustavi na vrednost rotirajuće sile koja je znatno ispod tačke frakture, može se izbeći lomljenje. Nekoliko automatizovanih sistema za pripremanje kanala korena uz pomoć rotacione sile su trenutno na tržištu: EndoStepper (S.E.T., Olching, Nemačka), Tri Auto ZX (Mortia, Kozoto, Japan) i ENDOflash (KaVo, Biberach, Nemačka). U poređnju sa drugim sistemima ENDOflash zauzima posebno mesto zato što je rotaciona sila kontrolisana mehaničkim a ne električnim putem.

KaVo ENDOflash sistem se sastoji od ENDOflash ručnog dela (Slika 1) sa integrisanom mehanički kontrolisanom rotacionom silom, ENDOflash iglica napravljenih od fleksibilnog nerđajućeg čelika, identične K-Flexo iglicama, i ENDOflash NiTi iglica, obe vrste iglica bez šiljka za sečenje (Slike 2 i 3).

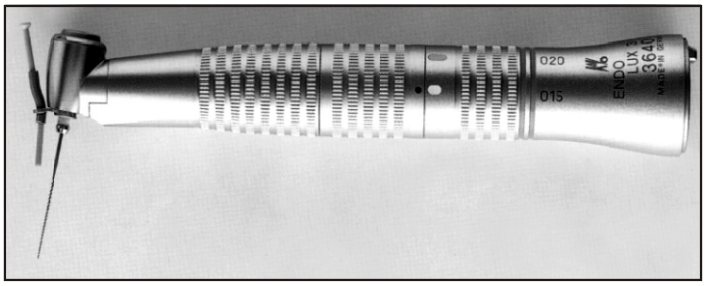
Prema instrukcijama proizvođača kolenjak sa integrisanim mikromotorom bi trebalo da se koristi pri maksimalnoj brzini od 10,000 rpm.

Introduction

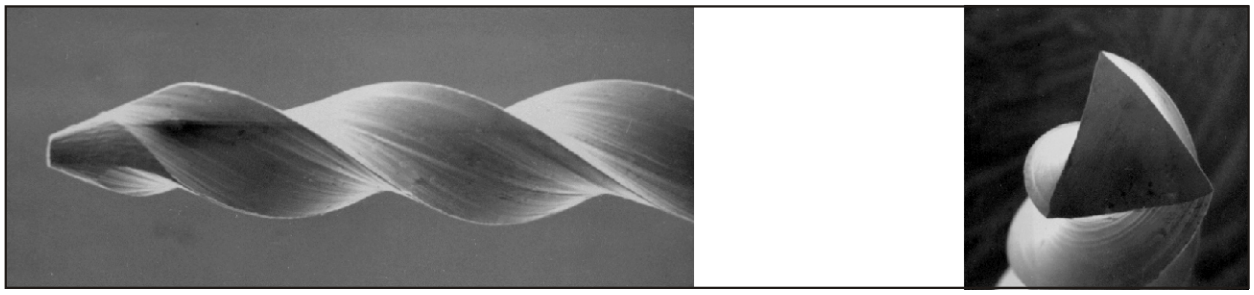
The main advantage of endodontic instruments manufactured of nickel-titanium alloys (NiTi) is their high flexibility which improves their ability to clean and shape even serverly curved root canals. The disadvantage is the - compared to stainless steel instruments - higher fracture rate. Because of this relatively increased risk of fracture during the rotary root canal preparation with NiTi-instruments new automated devices and/or handpieces were developed for improvement of the working safety (avoiding instrument fracture). This automated devices or handpieces, respectively, possess a special torque controlled rotation. The rotation of the root canal instrument is either stopped automatically or the direction of the rotation will be turned back as soon as the torque reaches the assigned limit during root canal preparation. The instrument does not rotate deeper into the root canal whereby a fracture of the instrument shall be avoided. The principle of the torque controlled rotation is based upon the fact that the resistance at the rotating instrument (torque) is increased, as soon as the instrument jams in the root canal or the friction is to high.[1,2] An instrument fracture will occur if the torque excesses a certain value which is characteristic for every instrument. If the rotation of the instrument will be stopped at a torque that is clearly below the fracture point a separation can be avoided. Several automated systems for root canal preparation with torque controlled rotation are currently on the market, for example EndoStepper (S.E.T, Olching, Germany), Tri Auto ZX (Morita, Koyoto, Japan) and ENDOflash (KaVo, Biberach, Germany). Compared to other new systems the ENDOflash has an exceptional position because the torque is controlled mechanically and not electronically.

The KaVo ENDOflash system consists of the ENDOflash handpiece (Fig. 1) with integrated mechanical torque control, ENDOflash files made of flexible stainless steel, identically to K-Flexofiles, and ENDOflash NiTi files, both with a non-cutting tip. (Figs. 2 and 3)

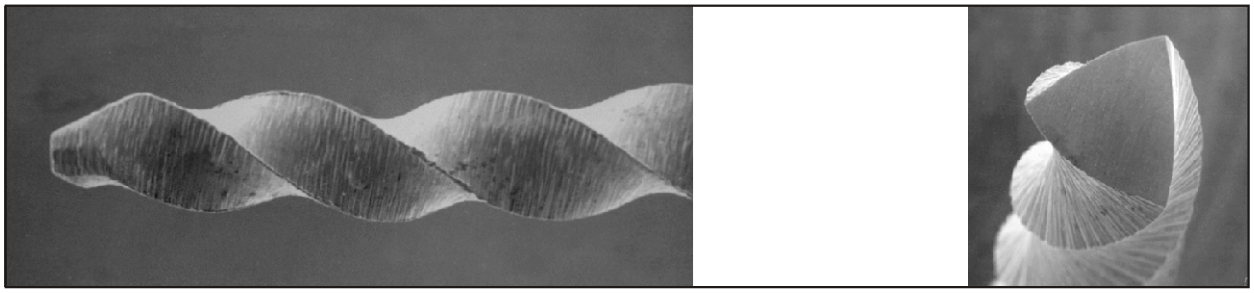
According to the manufacturers' instructions the handpiece with an integrated micro motor should be used with a maximal speed of 10,000



Slika 1. ENDOflash kolenjak
Fig. 1. The ENDOflash handpiece



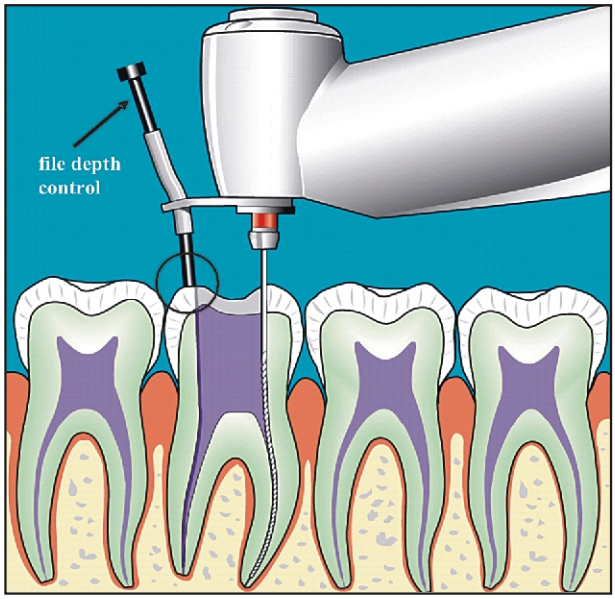
Slika 2. Skening elektromikroskopski izgled vrha igala za obradu kanala ENDOflash sistema (igle od čelika) ISO veličina 30 i izgled igle na poprečnom preseku (originalno uvećanje 60 puta)
Fig. 2. Scanning electron microscope image of the tip and the cutting flutes of an ENDOflash stainless steel file, ISO size 30 and the cross-sectional diameter (original magnification 60×)



Slika 3. Skening elektromikroskopski izgled vrha igala za obradu kanala ENDOflash sistema (igle od nikl-titanijuma), ISO veličina 30 i izgled igle na poprečnom preseku (originalno uvećanje 60 puta)
Fig. 3. Scanning electron microscope image of the tip and the cutting flutes of an ENDOflash nickel-titanium file, ISO size 30 and the cross-sectional diameter (original magnification 60×)

Zbog redukcije 40: 1 instrumenti se rotiraju brzinom od 250 rpm. Kolenjak može da se koristi sa odvojenim mikromotorom ili uz stomatološki aparat. Po mišljenju proizvođača najbolji rezultati u pripremanju kanala korena će biti postignuti pri brzini rotacije od 250-300rpm. Kolenjak sa zaobljenim glavenim delom od 100° ima "kontrolu dubine iglice" i integrisani izvor svetlosti sa jačinom do 25,000 lux. "Kontrola dubine iglice" na vrhu ručnog dela može da se prilagodi posebnim instrumentom za merenje do određene radne dužine (Slika 4). "Kontrola dubine iglice" slobodno pokretljive na 300° je onda prilagođena receptivnoj referentnoj tački na zubu. U sredini ručnog dela je rotirajući tip prstena za prilagođavanje koji dozvoljava selekciju tri različita po boji kodirana

rpm. Due to a 40 : 1 reduction the instruments are rotating with a speed of 250 rpm. The handpiece can be used with a separate micro motor or at the dental unit. According to the manufacturer the best results in root canal preparation will be reached at a speed of rotation at 250-300 rpm. The hand piece with a 100°-angled head has a "file depth control" and an integrated light source with power up to 25.000 lux. The "file depth control" at the head of the handpiece can be adjusted with a special measuring gauge to the determined working length (Fig. 4). The 300° free moveable "file depth control" is then adjusted to the respective reference point at the tooth. In the middle of the handpiece is a swivel type adjustment ring which permits the selection of three different,



Slika 4. Kontrola dubine uvođenja igle pomoću graničnika na glavi ENDOflash kolenjaka prilagođena referentnoj tački u zubu

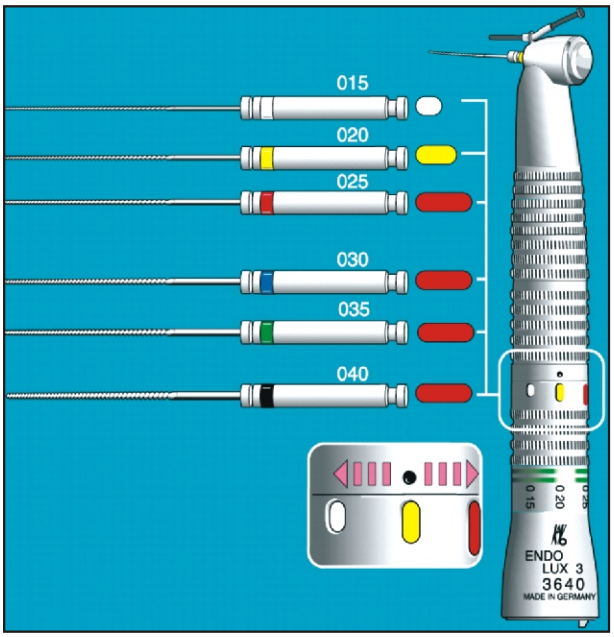
Figure 4. The "file depth control" at the head of the ENDO-flash handpiece adjusted to the reference point at the tooth

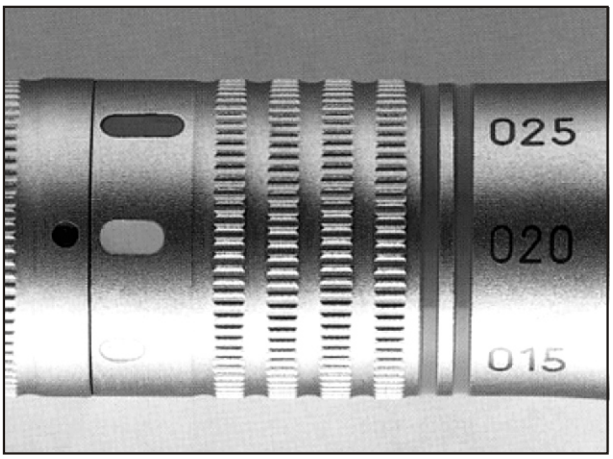
mesta za izbor veličine iglica (Slika 5). Ova mesta su u skladu sa veličinama iglica ENDO-flash od nerđajućeg čelika (Slika 6). Mogu se odabrati sledeća mesta sa rotacionom silom:

• Belo: za ENDOflash iglice veličine ISO 15(max. 0.04Nem)

• Žuto: za ENDOflash iglice veličine ISO 20(max. 0.08Nem)

• Crveno: za ENDOflash iglice veličine ISO 25 i veće (max. 0.14 Nem).





Slika 5. Okretni tip prstena za prilagođavanje i izbor različitih, bojom označenih, jačina obrtnog momenta

Figure 5. The swivel type adjustment ring for selection of the different, color-coded torque settings

color-coded torque settings (Fig. 5). These torque settings are in line with the sizes of the stainless steel ENDOflash files used in each case (Fig. 6). The following torque settings can be selected:

• white: for ENDOflash files of ISO size 15 (max. 0.04 Ncm)

• yellow: for ENDOflash files of ISO size 20 (max. 0.08 Ncm)

• red: for ENDOflash files of ISO size 25 and larger (max. 0.14 Ncm)

The principle of torque control is based on the fact that during rotation the torque will increase if the instrument jams in the root canal. As soon as the blades of the instrument cut into the root canal wall, the resistance increases due to friction and/or jamming of the instrument. When the adjusted instrument specific torque value is achieved the rotation of the instrument stops automatically (ATC = Automatic Torque Control). Because the rotation of the instrument used at this time stops at a torque value that is clearly below the fracture limit a separation can be avoided. The instrument is than moved by the dentist with the handpiece slightly out of the root canal in a coronally directed mode of operation whereby material is scrapped off. Thus, the linear operational movement bringing about the removal of the root canal dentin. So this is a

Slika 6. Šetmatski prikaz različitog podešavanja obrtnog momenta i veličine ENDOflash igala koji se upotrebljavaju u svakom pojedinačnom slučaju

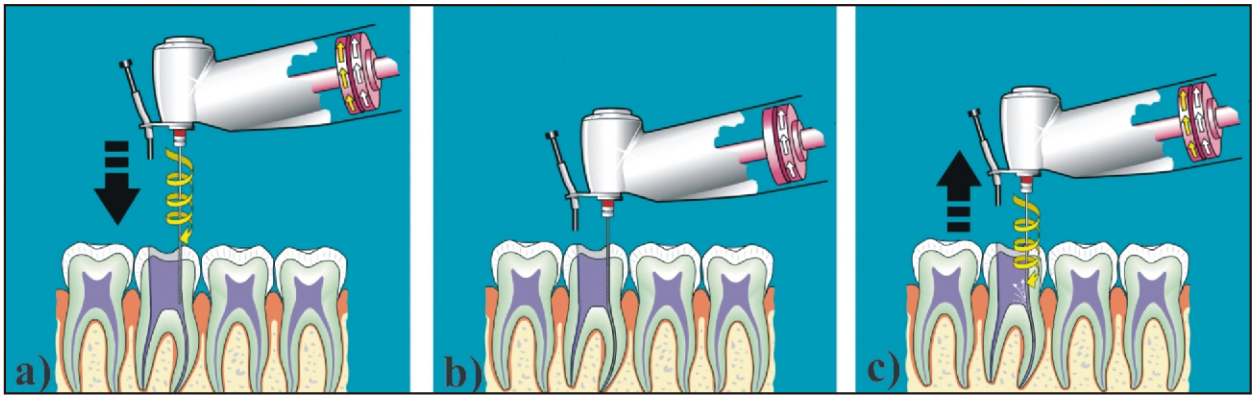
Figure 6. Schematic illustration of the different torque settings and the sizes of the ENDOflash instruments to be used in each case

Princip kontrole rotirajuće sile se bazira na činjenici da u toku rotacije može doći do povećanja rotacione sile ako se instrument zaglavi u kanalu korena. Čim se sečiva instrumenta zariju u zid kanala korena, otpornost se povećava zbog trenja i/ili u slučaju da se instrument zaglavi. Kada se postigne podešena specifična vrednost rotacione sile instrumenta, rotacija instrumenta odmah automatski prestaje (Automatska kontrola rotacione sile). Lomljenje se može izbeći s obzirom na to da se rotacija instrumenta koja se koristi u ovom periodu, zaustavlja u nivou rotacione sile koja je znatno ispod granice preloma. Zubar onda lagano pomera instrument, uz pomoć ručnog dela, van kanala korena kružnim pokretima pri čemu se materijal istruže. Na taj način linearni operativni pokret dovodi do otklanjanja dentina kanala korena. Ovaj sistem je dakle rotaciono-strugajući način operacije i može se uporediti sa radnim pokretima prikupljanja (Slika 7). Zbog toga je radni pokret baziran po principu ručne instrumentacije sa K iglicama. Kada je instrument opet slobodan u kanalu korena a sečiva više nisu u kontaktu sa zidovima kanala rotacija automatski počinje ponovo, i naredni radni ciklus je usmeren ka vrhu. Priprema bi trebalo da bude ritmički sled pokreta u pravcu krunice i vrha (Slika 7). Po instrukcijama proizvođača, trebalo bi izbegavati rotaciju kod koje nije uspostavljen kontakt instrumenta sa zidom kanala korena (uzaludna rotacija), zato

system with rotating-scrapping mode of operation comparable to a picking working motion (Fig. 7). Consequently, the working motion is based on the principle of the manual instrumentation with K-files. If the instrument is again free in the root canal and the cutting blades are no longer in contact with the canal walls the rotation starts again automatically and the next working cycle in direction to the apex follows. The preparation should be a rhythmical succeed of apically and coronally directed movements (Fig. 7). According to manufacturers' instructions a rotation without contact of the instrument with the root canal wall (idle rotation) should be avoided because this can result in undesired alterations of the original shape of the root canal and a needless stress of the files (Fig. 8). During root canal preparation no more force should be applied than used by writing with a pointed pencil. The force pointed to the apex should be as little as possible. Beside the usual root canal preparation technique also the “step down” or the “crown down” techniques can be used.

Review of the literature
Shaping ability and cleaning capacity

Although, the ENDOflash system is already on the market for several years, only a few studies concerning the efficiency and safety of



Slika 7. Šematski prikaz načina rada: a) instrument se ubacuje u kanal pod stalnom rotacijom; b) pošto se postigne specifični i željeni obrtni moment rotacija instrumenata se automatski prekida; c) kada se to desi, instrumenti mora delimično da budu izvučeni iz kanala korena u suprotnom pravcu obrtanja igle u radnom stanju.

Figure 7. Schematic illustration of the picking working motion: a) the instrument is introduced into the root canal under permanent rotation; b) as soon as the specific torque value is reached the rotation of the instrument stops automatically; c) once that happens, the instrument must be partially extracted from the root canal in an out filing motion

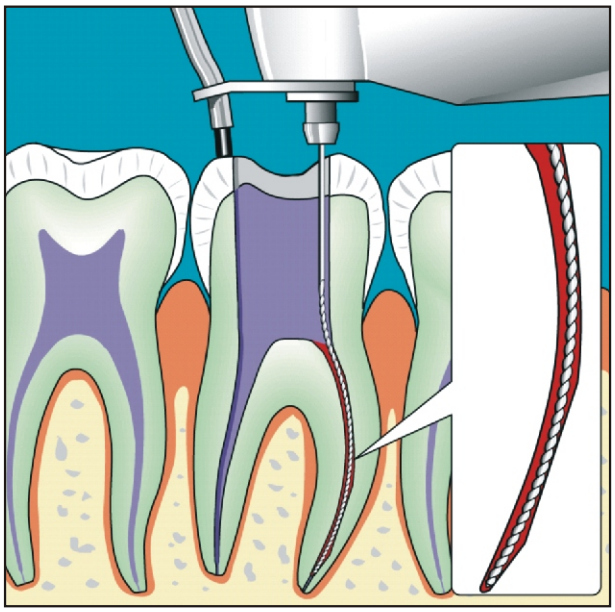
što on može voditi u promeni originalnog oblika kanala korena i nepotrebnom naglom stresu iglice (Slika 8). U toku pripreme kanala korena ne bi trebalo upotrebljavati veću silu od one koja se upotrebljava pri pisanju zašiljenom olovkom. Sila usmerena ka vrhu bi trebalo da bude što je moguće manja. Pored uobičajene tehnike pripreme kanala korena može se koristiti i "korak niže" ili "krunica niže" tehnika.

Pregled literature

Sposobnost menjanja oblika i kapaciteta čišćenja

Iako je ENDOflash sistem prisutan na tržištu već nekoliko godina, objavljeno je samo nekoliko studija koje se tiču efikasnosti i bezbednosti sistema. Schafer i Zapke[3] su uporedili efikasnost ručne i mašinske pripreme pravog i iskrivljenog kanala korena putem skening elektron mikroskopije (SEM). Ručna instrumentacija je obavljena pomoću K-Flexo iglica i Hedstrom iglica. K-Flexo iglice su korišćene uz proširujuće radne pokrete koristeći korak unazad tehniku, dok su Hestrom iglice korišćene uz pokrete punjenja. Automatska priprema kanala korena izvedena je pomoću KaVo ENDOflash sistema koristeći K-Flexo iglice od nerđajućeg čelika i ProFile sistema (Dentsply Maillefer, Ballaigues, Švajcarska) koristeći rotacione NiTi instrumente. Po grupi je pripremljeno 12 ljudskih zuba, svaki ili sa pravim ili sa iskrivljenim kanalom korena do ISO veličine 40. Kvantifikovana je količina otpadnog materijala i razmaznog sloja. U svim grupama je postignuta bolja efektnost čišćenja kod pravih nego kod iskrivljenih kanala korena. I kod pravih i kod iskrivljenih kanala, manuelna instrumentacija pri kojoj su korišćene Hedstrom iglice postigla je najbolju čistoću kanala uz pra-

the system are published. Schäfer and Zapke (3) compared the efficacy of manual and mechanical preparation of straight and curved root canals by scanning electron microscopy (SEM). The hand instrumentation was performed with K-Flexofiles and Hedström files. K-Flexofiles were used in a reaming working motion using the step-back-technique whereas Hedström files were used in a filing motion. Automated root canal preparation was performed with the KaVo ENDOflash system using stainless steel K-Flexofiles and with the ProFile system (Dentsply Maillefer, Ballaigues, Switzerland) using rotary NiTi instruments. Per group 12 extracted human teeth each with either straight or curved root canals were prepared to ISO size 40. The amount of debris and smear layer was quantified. In all groups a better cleaning effectiveness was achieved in straight than in curved root canals. Both in the straight and in the curved canals, the manual instrumentation using Hedström files achieved the best canal cleanliness followed by the K-Flexofiles. The ProFile system showed the least effective cleaning whereas ENDOflash brought a middle position. With manual preparation as well as after using ENDOflash the incidence of uninstrumented canal wall areas appeared markedly less compared to instrumentation with the ProFile system. In contrast, the best instrumentation results, especially in curved



Slika 8. Neželjeno oblikovanje u slučaju rotacije igle bez kontakta radnih površina sa zidom kanala korena. Ovakva situacija treba da bude izbegnuta da bi se smanjila incidenca oštećenja kanala korena zuba

Figure 8. Undesired shaping effects in case of rotation of the instrument without contact of the cutting edges with the root canal wall. This should be avoided in order to minimize incidence of canal aberrations

tnju K-Flexo iglica. ProFile sistem je pokazao najmanju efikasnost pri čišćenju dok je ENDOflash doveo do srednje pozicije. Uz ručnu pripremu kao i posle korišćenja ENDOflash, neobrađene površine kanala su se pojavile u znatno manjoj meri u poređenju sa instrumentacijom uz pomoć ProFile sistema. Suprotno tome, najbolji rezultati instrumentacije a naročito u iskrivljenim kanalima su obezbeđeni putem ProFile sistema.

Najlošiji oblici kanala bili su rezultat ručne upotrebe Hedstrom iglica, dok je ručna instrumentacija sa K- Flexo iglicama i automatska priprema sa KaVo ENDOflash sistemom pokazala prihvatljive rezultate instrumentacije. Autori su zaključili da je ENDOflash uređaj postigao ekvivalentni stepen čišćenja kanala korena u poređenju sa ručnom pripremom.[3]

Fariniuk et al.[4] je uporedio ENDOflash iglice od nerđajućeg čelika i ProFile NiTi iglice u vezi sa apikalnim prodorom u simuliranim kanalima iskrivljenog korena. Dvadeset i četiri simulirana kanala korena sa 30° zakrivljenosti su nasumice podeljeni u dve grupe i pripremljeni sa ENDOflash ili ProFile iglicama prema uputstvima proizvođača. Upoređivanja simuliranih kanala korena pre i posle instrumentacije pokazalo je značajne razlike između grupa, uz veći prodor ostvaren ENDOflash iglicama. Primećen je jedan slučaj deformacije sa ProFile instrumentom ali nije bilo lomljenja iglica. Do sličnih rezultata došlo se kod izvađenih ljudskih zuba korišćenjem ENDOflash iglica od nerđajućeg čelika sa ENDOflash sistemom ili NiTi iglicama sa ProFile sistemom.[5] Dvadeset mezio bukalnih kanala korena iz izvađenih ljudskih maksilarnih kutnjaka je analizirano putem digitalne radiografije. Uzimajući u obzir apikalni prodor upotreba ENDOflash iglica je rezultirala znatno većim ispravljanjem u toku instrumentacije. Autori su prijavili jedno lomljenje instrumenta kod ProFile grupe i dva slučaja deformacije iglice kod ENDOflash grupe.[5]

Amin i De Brie[6] su izvršili procenu čistoće kanala korena posle manuelne i automatske instrumentacije putem SEM, in vitro. Koreni kanala izvađenih ljudskih kutnjaka su ručno pripremani sa Nitflex K-iglicama (Dentsply

canals were obtained with the ProFile system. The poorest canals shapes resulted in the manual use of Hedström files, whereas the hand instrumentation with K-Flexofiles and the automated preparation with the KaVo ENDOflash system showed acceptable instrumentation results. The authors concluded that the ENDOflash device achieved an equivalent degree of root canal cleaning compared to manual preparation.[3]

Fariniuk et al.[4] compared ENDOflash stainless steel files and ProFile NiTi files concerning the apical transportation in simulated curved root canals. Twenty-four simulated root canals with a 30° curvature were randomly divided into two groups and prepared with ENDOflash or ProFile files according to manufacturers' instructions. Comparisons between the simulated root canals before and after instrumentation showed significant differences between the groups, with greater transportation created by ENDOflash files. One case of deformation was observed with a ProFile instrument and there were no fractures of files. Similar results were obtained in extracted human teeth using ENDOflash stainless steel files with the ENDOflash system or NiTi files with the ProFile system.[5] Twenty mesio-buccal root canals from extracted human maxillary molars were analyzed by digital radiography. Considering apical transportation the use of ENDOflash files resulted in a significantly greater straightening during instrumentation. The authors reported one instrument fracture in the ProFile group and two cases of file deformation in the ENDOflash group.[5]

Amin and De Brie[6] evaluated the root canal cleanliness after manual and automated instrumentation by SEM in vitro. The root canals of extracted human molars were prepared manually with Nitiflex K-files (Dentsply Maillefer, Ballaigues, Switzerland) according to the balanced force technique or mechanically with ENDOflash stainless steel K-files. Straight root canals were instrumented to ISO size 60 and curved to ISO size 40. Eight curved and two straight root canals per group were examined by SEM for debris and smear layer. The amount of debris was significant lower in the mechanically

Maillefer, Ballaigues, Švajcarska) prema balansnoj sili tehnike, ili mehanički sa ENDOflash K-turpijma od nerđajućeg čelika. Pravi kanali korena obrađivani su do ISO 60 veličine a zakrivljeni do ISO 40. Osam iskrivljenih i dva prava kanala korena ispitani su po grupama pomoću SEM zbog ostataka razmazanog sloja. Količina ostatka bila je znatno manja u mehanički instrumentovanom kanalu korena ali nije bilo značajnih razlika između ove dve grupe, što se tiče razmazanog sloja. Takođe su, neobrađene površine zidova kanala češće bile vidljivije posle ručne pripreme[6].

Fariniuk et al.[7] analizirali su kapacitet čišćenja endodontskih instrumenata aktiviranih putem ENDOflash sistema. Izvršeno je ispitivanje sledećih instrumenata: ENDOflash 02 iglica od nerđajućeg čelika, ProFile 04 NiTi iglica (Dentsply Maillefer, Ballaigues, Švajcarska), i Pow-R 04 NiTi iglice (Moyco-Union Broach, York, SAD). NiTiflex iglice (Dentsply Maillefer) – ručni instrumenti služili su kao pozitivna kontrola. Dvadeset dva izvađena ljudska maksilarna kutnjaka obrađivani su do ISO veličine 35 i ispirani samo destilovanom vodom. Ispitivanje ostataka, pod svetlosnim mikroskopom, pokazalo je značajne razlike. 97.14% zidova kanala korena na kojima se debris nije zadržao bili su posledica Profile instrumentacije kanala; 77.4% Pro-R iglicama, 67.53% NiTiflex iglicama i 63.56% ENDOflash iglicama. Na taj način, ENDOflash iglice od nerđajućeg čelika pokazale su najniži nivo čišćenja kanala korena, niži od NiTi ručnih instrumenata.

Schulte-Lunzum[8] je izvršio procenu ENDOflash sistema sa tri različite vrste iglica (ENDOflash fleksibilne iglice od nerđajućeg čelika, NiTi K-iglice i VDW (Munich, Nemačka fleksibilne iglice od nerđajućeg čelika K-Reamer) uzimajući u obzir vreme pripreme, gubitak radne dužine, lomljenje instrumenata i ispravljanje kanala. Šezdeset izvađenih ljudskih zuba sa zakrivljenošću od >25° odabrani su i pripremljeni od veličine ISO 15 do 35. Vreme pripreme se kretalo između 2min 42 sek (ENDOflash NiTi), 2min 59sec(K-Reamer) i 3min/26sec (ENDOflash od nerđajućeg čelika). Nije bilo značajnih razlika. Utvrđen je znatno instrumented root canals but there were no significant differences between the two groups considering smear layer. Also untreated canal wall areas were shown more often after manual preparation.[6]

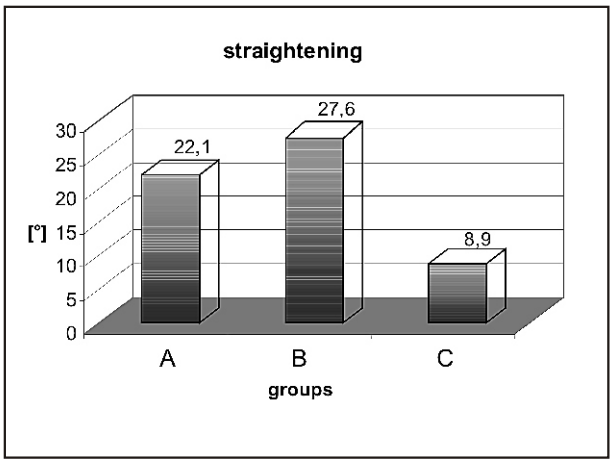
Fariniuk et al.[7] analyzed histologically the cleaning capacity of endodontic instruments activated by the ENDOflash system. The following instruments were investigated: ENDOflash taper 02 stainless steel files, ProFile taper 04 NiTi files (Dentsply Maillefer, Ballaigues, Switzerland), and Pow-R taper 04 NiTi files (Moyco-Union Broach, York, USA). Nitiflex files (Dentsply Maillefer) hand instruments served as a positive control. Twenty-two extracted human maxillary molars were instrumented to ISO size 35 and irrigated with distilled water only. The light microscopic evaluation of the debris showed significant differences. 97.14 % debris-free root canal walls were shown in canals instruments with ProFile, 77.4 % with Pow-R files, 67.53 % with Nitiflex files and 63.56 % with ENDOflash files. Thus, ENDOflash stainless steel files showed the lowest levels for cleaning the root canal, lower than NiTi hand instrumentation.

Schulte-Lünzum[8] evaluated the ENDOflash system with three different types of files (ENDOflash flexible stainless steel, NiTi K-Files, and VDW (Munich, Germany) flexible stainless steel K-Reamer) with regard to preparation time, loss of working length, instrument fracture and canal straightening. Sixty extracted human teeth with a curvature > 25° were selected and prepared from ISO size 15 to ISO size 35. The preparation times ranged between 2 min 42 sec (ENDOflash NiTi), 2 min 59 min (K-Reamer) and 3 min 26 sec (ENDOflash stainless steel). The differences were not significant. The significantly slightest loss of working length was found for ENDOflash NiTi with 0.23 mm, whereas with ENDOflash stainless steel file a loss of working length of 1.75 mm and with the K-Reamers a loss of 3.25 mm resulted, respectively. A fracture or a visible permanent deformation occurred in none of the instruments. Concerning canal straightening significant differences between the three types of instruments were found (Fig. 9). The slightest straightening showed ENDOflash NiTi files

manji gubitak radne dužine 1.75mm za ENDOflash iglice od nerđajućeg čelika a za K-Reamers gubitak od 3.25mm. Lomljenje ili trajni vidljivi deformitet se nije ispoljio ni kod jednog od navedenih instrumenata. Kada je reč o ispravljanju kanala, pronađene su značajne razlike između tri tipa instrumenata (Slika 9). ENDOflash NiTi iglice pokazale su neznatnu stopu ispravljanja (8.9°), ENDOflash iglice od nerđajućeg čelika (22.1%) i K-Reamers (27.6%). Kod 6 zuba je došlo do perforacija kanala korena: dva u ENDOflash grupi od nerđajućeg čelika, i četiri u K-Reamer grupi (Slika 10). ENDOflash NiTi grupa nije uopšte ispoljila perforacije.[8]

Gerbert i Hulsmann[9] sproveli su studiju u vezi sa mehaničkom pripremom kanala korena sa ENDOflash sistemom uz korišćenje različitih tipova instrumenata: fleksibilni ENDOflash od (8.9°), followed by ENDOflash stainless steel files (22.1°) and K-Reamers (27.6°). Root canal perforations occurred in six teeth: two in the ENDOflash stainless steel group and four in the K-Reamer group (Fig. 10). The ENDOflash NiTi group showed no perforations.[8]

Gerbert and Hülsmann[9] conducted a study on the mechanical root canal preparation with the ENDOflash system using different types of instruments: ENDOflash flexible stainless steel and NiTi K-files as well as GT Rotary NiTi-Files (Dentsply Maillefer). Forty-five extracted human mandibular molars with curved root canals were instrumented to ISO size 45 by the crown-down-technique. The following parameters were evaluated: instrument fracture, perforations, loss of working length, apical blockage, cleanliness of the root canal walls, the diameter form of the canals after preparation,

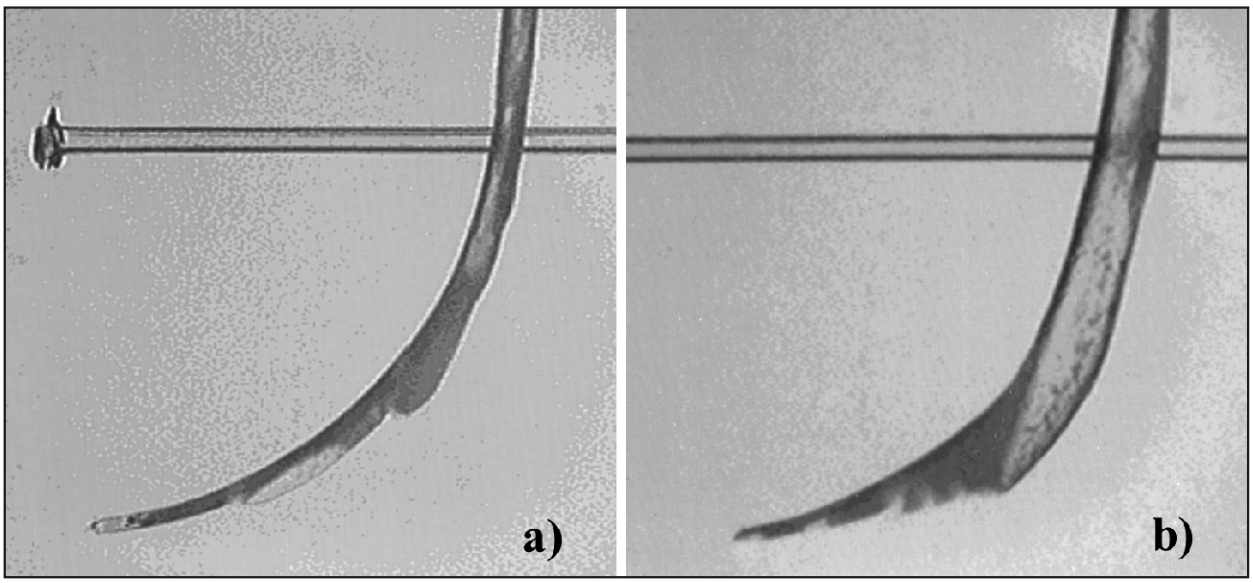


Slika 9. Ispravljanje [°] zakrivljenih kanala korena posle preparacije kanala korena sa ENDOflash kolenjakom sa različitim tipovima iglica po Schulte-Lünzum (8): grupa A: ENDOflash čelične iglice, grupa B: čelični reamers, grupa C: ENDOflash nikl-titanijumske iglice.

Figure 9. Straightening [°] of curved canals after root canal preparation using the ENDOflash handpiece with different types of instruments as reported by Schulte-Lünzum (8): group A: ENDOflash stainless steel files; group B: stainless steel reamers; group C: ENDOflash nickel-titanium files

Slika 10. Reprezentativni primeri oblikovanja zakrivljenih kanala od 28° kao rezultat rada sa (a) čeličnim reamers i (b) ENDOflash čeličnim iglicama. Primećuje se nezadovoljavajući oblik kanala posle preparacije sa ovim čeličnim instrumentima.

Figure 10. Representative examples of canal shapes of 28° curved canals as the result of instrumentation with (a) stainless steel reamers and (b) ENDOflash stainless steel instruments. Notice the unsatisfactory canal shapes after preparation with these stainless steel instruments



nerđajućeg čelika, NiTi K-iglice kao i GT rotacione NiTi-iglice (Dentsply Maillefer). Četrdeset i pet izvađenih ljudskih mandibularnih kutnjaka sa iskrivljenim kanalima korena, obrađivani su do ISO veličine od 45, putem "krunica na niže" tehnike. Vrednovani su sledeći parametri: lomljenje instrumenata, perforacije, gubitak radne dužine, apikalna blokada, čistoća zidova kanala korena, dijametar kanala posle pripreme, ispravljanje kanala korena i vreme pripreme. Što se tiče ispravljanja iskrivljenog kanala korena nisu nađene značajne razlike između dve vrste NiTi iglice ali su instrumenti od nerđajućeg čelika dali znatno gore rezultate. Uzimajući u obzir dijametar post operativnog kanala korena i procenat pripremljenog prečnika kanala korena nije bilo bitnih kliničkih razlika među grupama. Što se tiče čistoće kanala korena, GT Rotary instrument se pokazao neuporedivo gore od svih ostalih. Upotreba GT rotacionog instrumenta je izazvala 4 lomljenja instrumenta, četiri perforacije sa ENDOflash instrumentima od nerđajućeg čelika i dve perforacije sa ENDOflash NiTi iglicama. Radno vreme bilo je znatno kraće za NiTi iglice nego za instrumente od nerđajućeg čelika[9].

Meister i Hulsmann[10] su in vitro ispitali mehaničku pripremu kanala korena sa ENDOflash sistemom korišćenjem različitih tehnika: ENDOflash fleksibilni nerđajući čelik i NiTi K-iglice uz korišćenje standardne tehnike i ENDOflash NiTi iglice korišćene od krunice na niže. 45 izvađenih ljudskih mandibularnih kutnjaka sa iskrivljenim kanalima korena instrumentovani su do ISO veličine od 45. Analizirani su sledeći kriterijumi: lomljenje instrumenta, perforacija, gubitak radne dužine, apikalna blokada, čistoća zidova kanala korena, dijametar kanala posle pripreme, ispravljanje kanala korena i vreme pripreme. Što se tiče ispravljanja iskrivljenog kanala korena nisu primećene značajne razlike između dve tehnike pripreme uz pomoć NiTi instrumenata. Instrumenti od nerđajućeg čelika pokazali su znatno lošije rezultate i pokazale neznatno ispravljanje kanala korena. Što se tiče postoperativnog dijametra kanala korena i čistoće kanala korena, nisu pronađene bitne kliničke razlike. Ni kod

root canal straightening and preparation time. Regarding straightening of the curved root canals no significant differences between the two NiTi files were found but stainless steel instruments yielded significantly worse results. With regard to the post-operative root canal diameter and the percentage of prepared root canal circumference no clinical relevant differences existed between the groups. Concerning the root canal cleanliness, GT Rotary instruments preformed significantly worse than all other instruments. Four instrument fractures occurred with GT Rotary, four perforations with the ENDOflash stainless steel instruments and two perforations with the ENDOflash NiTi files. Working time was significantly shorter for the NiTi files than for the stainless steel instruments[9].

Meister and Hülsmann[10] investigated in vitro the mechanical root canal preparation with the ENDOflash system using different techniques: ENDOflash flexible stainless steel and NiTi K-Files using the standard technique and ENDO-flash NiTi files used according to the crown-down-technique. Forty-five extracted human mandibular molars with curved root canals were instrumented to ISO size 45. The following criteria were analyzed: instrument fracture, perforations, loss of working length, apical blockage, cleanliness of the root canal walls, the diameter form of the canals after preparation, root canal straightening and preparation time. Regarding straightening of the curved root canals no significant differences between the two preparation techniques using NiTi instruments were detected. Stainless steel instruments displayed significantly worse results and showed marked straightening of the root canal. With regard to the post-operative root canal diameter and the root canal cleanliness no clinical relevant differences were obtained. Instrument fractures occurred with none of the techniques, but the stainless steel files produced six apical perforations in a total of 30 root canals treated. Using NiTi files in the standard technique one perforation and one loss of working length occurred. One perforation, one apical blockage and one loss of working length were observed during instrumentation

jedne od ovih tehnika nisu primećene frakture, ali su iglice od nerđajućeg čelika stvorile 6 apikalnih perforacija u celokupnom broju od 30 tretiranih kanala korena. Korišćenjem NiTi iglica u standardnoj tehnici došlo je do jedne perforacije i jednog slučaja gubitka radne dužine. Jedna perforacija, jedna apikalna blokada i jedan gubitak radne dužine primećeni su u toku instrumentacije upotrebom krunica – niže tehnike. Radno vreme je bilo znatno niže za NiTi instrumente nego za instrumente od čelika.[10]

Paque et al.[11] analizirali su količinu ostataka stvorenu putem FlexMaster (VDW, Munich, Nemačka) i GT Rotary (Dentsply Maillefer) NiTi iglica u poređenju sa ENDOflash iglicama od nerđajućeg čelika, kod 45 izvađenih ljudskih prvih i drugih maksilarnih kutnjaka sa iskrivljenim mezio-bukalnim korenovima (>20°). ENDOflash priprema je stvorila više debrisa na vrhu od FlexMaster. Nije pronađena ni jedna značajna razlika između ENDOflash i GT Rotary iglica. [11]

Radna bezbednost

Pri proceni svih navedenih podataka, ENDOflash kolenjak testiran je u 209 kanala korena sa ENDOflash iglicama od nerđajućeg čelika i u 80 kanala sa ENDOflash NiTi iglicama. Od 209 slučajeva tretiranih ENDOflash čeličnim iglicama, nije se desila fraktura instrumenta a takođe i u 80 kanala obrađivanih ENDOflash NiTi iglicama. Nasuprot ovoj konstataciji, u četiri od 30 kanala oblikovanih sa GT Rotary iglicama korišćenjem ENDOflash kolenjaka došlo je do odvajanja GT Rotary iglica (13.3% slučajeva je povezano sa brojem kanala). U jednom od 27 kanala proširenih sa NiTi ProFile instrumentima korišćenjem ENDOflash ručnog dela primećeno je odvajanje (3.7% slučajeva je povezano sa brojem kanala).

Ukratko, ENDOflash kolenjak je veoma bezbedan kada se koriste NiTi ENDOflash iglice ili iglice od nerđajućeg čelika. Mašinskoj obradi kanala korena NiTi iglicama, uz korišćenje ENDOflash kolenjaka mora se pristupiti sa oprezom zato što su u nekoliko slučajeva opisani prelomi u literaturi.

using the crown-down-technique. Working time was significantly shorter for the NiTi instruments than for the steel instruments.[10]

Paqué et al.[11] analyzed the amount of debris produced by FlexMaster (VDW, Munich, Germany) and GT Rotary (Dentsply Maillefer) NiTi files compared to stainless steel ENDOflash files in 45 extracted human maxillary first and second molars with curved mesio-buccal roots (> 20°). ENDOflash preparation produced significantly more debris at the apex than FlexMaster. No significant difference was found between ENDOflash and GT Rotary files.[11]

Working safety

Evaluating all cited data the ENDOflash handpiece was tested in 209 root canals with ENDOflash stainless steel files and in 80 canals with ENDOflash NiTi Files. Out of the 209 cases treated with ENDOflash stainless steel files no instrument fracture occurred and also in the 80 canals enlarged with ENDOflash NiTi files no separation was reported. On the contrary, in four out of 30 canals shaped with GT Rotary files using the ENDOflash handpiece a separation of the GT Rotary files occurred (incidence 13.3 % related to the number of the canals). In one out of 27 canals enlarged with NiTi ProFile instruments using the ENDOflash handpiece a separation was noticed (incidence 3.7 % related to the number of the canals).

In summary, the ENDOflash handpiece was very safe when stainless steel or NiTi ENDOflash files were used. Automated root canal preparation with NiTi files having greater tapers than 2 % using the ENDOflash handpiece must be done with some degree of caution because in several cases fractures of the files ave been described in the literature.

Discussion

Regarding the literature it can be concluded that the torque limitation of the ENDOflash handpiece is very effective in preventing

Diskusija

Uzimajući u obzir literaturu može se zaključiti da je ograničenje rotacione sile kod ENDOflash (kolenjaka) veoma efektivno u sprečavanju lomljenja ENDOflash igala od nerđajućeg čelika i NiTi instrumenata u toku pripreme kanala korena. Ni u jednoj od navedenih studija nije došlo do frakture ENDOflash nerđajućeg čelika ili ENDOflash NiTi iglica. Jedino je Fariniuk et al.[5] prijavio deformacije iglica od nerđajućeg čelika. Ukratko se može zaključiti da je, što se tiče radne sigurnosti ENDOflash sistem prilično sigurno automatsko sredstvo.

Očigledno, problem ENDOflash sistema je upotreba iglica od nerđajućeg čelika kod ispravljanja i prodora duž iskrivljenih kanala. Svi autori su, upoređivajući oblike iskrivljenog kanala korena pre i posle instrumentacije, prijavili nezadovoljavajuće rezultate sa ENDOflash iglicama od nerđajućeg čelika.[4,5,8-10] Međutim, ENDOflash NiTi iglice su daleko bolje održale formu iskrivljenih kanala.[8-10] Nezavisno od tehnike pripreme koja se koristi, ENDOflash NiTi iglice su bile superiornije u odnosu na ENDOflash instrumente od nerđajućeg čelika.[10] U poređenju s mehaničkim NiTi sistemom, ENDOflash NiTi iglice nude iste rezultate pripreme i u iskrivljenim kanalima korena.[9] Što se tiče čistoće kanala korena objavljeni su kontradiktorni rezultati ali se mora imati na umu da je kompletno čišćenje kanala korena od ostataka razmazanog sloja trenutno nemoguće bilo sa nerđajućim čelikom ili NiTi instrumentima.[10] Neki autori su objavili da ENDOflash instrumenti od nerđajućeg čelika proizvode manje ostataka ili razmazanog sloja od nekih rotacinih NiTi iglica (GT Rotay).[9-11] U poređenju sa ručnim instrumentima ENDOflash instrumenti od nerđajućeg čelika su efektivniji u čišćenju kanala korena od ostataka nego NiTi ručni instrumenti[6] ali manje efektini od Hedstrom iglica od nerđajućeg čelika.[3] Samo je Farinuk et al.[7] objavio da ENDOflash iglice od nerđajućeg čelika pokazuju nižu efikasnost čišćenja u kanalima korena u poređenju sa NiTi ručnim i rotacionim iglicama.

U poređenju sa GT Rotary[9] i ENDOflash iglicama od nerđajućeg čelika[9,10] obrada kanala korena je bila brža sa ENDOflash NiTi

separation of ENDOflash stainless steel or NiTi instruments in the course of root canal preparation. In none of the cited studies a fracture of an ENDOflash stainless steel or an ENDOflash NiTi file occurred. Only Fariniuk et al.[5] reported deformations of stainless steel files. In summary, it can be concluded that concerning working safety the ENDOflash system seems to be a very safe automated device.

Obviously, a problem of the ENDOflash system is the use of stainless steel files regarding straightening and transportation of curved canals. All authors comparing the shapes of curved root canals before and after instrumentation reported unsatisfactory results with ENDOflash stainless steel files.[4,5,8-10] In contrast, ENDOflash NiTi files respected the shape of the curved canals far better.[8-10] Independently of the preparation technique used the ENDOflash NiTi files were superior to ENDOflash stainless steel instruments.[10] Compared to other mechanical NiTi systems, ENDOflash NiTi files seem to offer equal preparation results in curved root canals.[9] Concerning root canal cleanliness contradictory results are published but it has to be kept in mind that a complete cleaning of the root canal from debris and/or smear layer seems currently to be impossible either with stainless steel or with NiTi instruments.[10] Some authors reported that ENDOflash stainless steel instruments produce less debris and/or smear layer than some rotary NiTi files (GT Rotary).[9-11] Compared to hand instruments ENDOflash stainless steel instruments are more effective in cleaning the root canal from debris than NiTi hand instruments[6] but less effective than stainless steel Hedström files.[3] Only Fariniuk et al.[7] reported that ENDOflash stainless steel files showed the lowest cleaning efficiency in root canals compared to NiTi hand and rotary files.

In comparison to GT Rotary[9] and ENDOflash stainless steel files[9,10] root canal instrumentation was faster with ENDOflash NiTi instruments.[9,10] The instrumentation technique (standard or crown down) had no influence on the preparation time with ENDOflash NiTi files.[10]

The ENDOflash offers good results in mechanical root canal preparation when used with NiTi files.

instrumentima.[9,10] Instrumentacione tehnike (standardne ili krunica na niže) nisu imale uticaja na vreme pripreme sa ENDOflash NiTi iglicama.[10]

ENDOflash nudi dobre rezultate u mašinskoj pripremi kanala korena kada se upotrebljava sa NiTi iglicama.

Pregled

Kao uspešan model, KaVo sada nudi ENDOadvance (KaVo, Biberach, Nemačka) kolenjak (Slika 11). Prema uputstvima proizvođača 40.000 rpm je maksimalna brzina kolenjaka. Zbog redukcije od 120:1, instrument se rotira brzinom od 333 rpm. Kolenjak, takođe, ima glaveni deo pod uglom od 100° i integrisani izvor svetlosti od 25,000 lux ali ne i "kontrolu dubine iglice". Mogu se odabrati četiri različita mesta rotacione sile (Slika 12):

- Nivo 1 = 0.25 Ncm
- Nivo 2 = 0.50 Ncm
- Nivo 3 = 1.00 Ncm
- Nivo 4= 3.00 Ncm

ENDOadvance kolenjak trebalo bi da se koristi samo sa NiTi iglicama. Lista NiTi iglica koje se mogu koristiti sa ENDOadvance ručnim delom i preporučena mesta rotacione sile mogu se naći na www.kavo.de/endo. Rotaciona sila kontroliše kolenjak putem integrisane klizajuće pedale koja zaustavlja rotaciju iglice ako se dostigne preporučena rotaciona sila. Čim se aktivira dugme za rotacionu silu, čuje se zvuk i može se primetiti

Slika 11. Novi ENDOadvance kolenjak

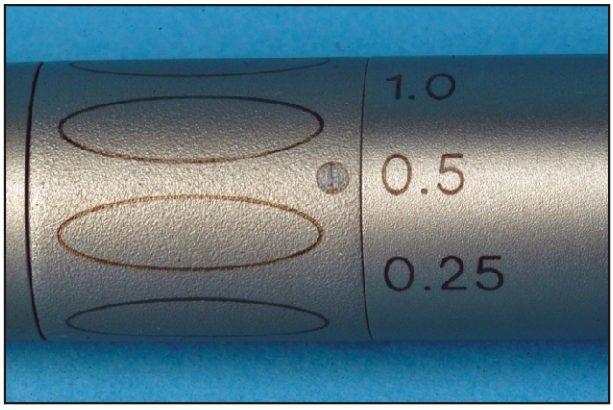
Figure 11. The new ENDOadvance handpiece

Outlook

As a succeeding model KaVo now offers the ENDOadvance (KaVo, Biberach, Germany) handpiece (Fig. 11). According to the manufacturers' instructions 40,000 rpm is the maximal speed of the handpiece. Due to a 120 : 1 reduction an instrument is then rotating with a speed of 333 rpm. The handpiece has also a 100°-angled head and an integrated light source with power up to 25,000 lux but no longer a "file depth control". Four different torque settings can be adjusted (Fig. 12):

- Stage 1 = 0.25 Ncm
- Stage 2 = 0.50 Ncm
- Stage 3 = 1.00 Ncm
- Stage 4 = 3.00 Ncm

The ENDOadvance handpiece should be used only with NiTi files taper > 2 %. A list of the NiTi files that can be used with the ENDOadvance handpiece and the recommended torque settings can be found at www.kavo.de/endo. For torque control the handpiece has an integrated glide clutch that stops the rotation of the file if the recommended torque is reached. As soon as the glide clutch is activated a clicking sound is audible and a



Slika 12. Novi ENDOadvance kolenjak sa okretnim tipom prstena za prilagođavanje i izbor četiri različite jačine obrtnog momenta. Za razliku od ENDOflash kolenjaka, različite jačine obrtnog momenta nisu više označene po boji

Figure 12. The swivel type adjustment ring of the ENDO advance handpiece for selection of four different torque settings. Notice that in contrast to the ENDOflash handpiece the different torque settings are no longer color-coded

vibriranje. Ako je upaljeno dugme za rotacionu silu terapeut treba da zaustavi motor, isključi rotaciju u levo, restartuje motor i izvadi iglicu iz kanala korena bez pritiska.

Trenutno se ne može proceniti koliko je ENDO-advance sistem napredniji od ENDO-flash-a zato što još uvek nema objavljenih rezultata studije, koje su upoređivale ova dva sistema.

Zaključak

ENDOflash kolenjak korišćen sa ENDO-flash NiTi je siguran sistem za mehaničku pripremu kanala korena. Prema literaturi, upotreba ENDOflash iglica od nerđajućeg čelika se ne može preporučiti zbog nezadovoljavajuće sposobnosti prilagođavanja. Trenutno se ne može proceniti koliko je ENDO-advance sistem napredniji od ENDOflash-a zato što još uvek nema objavljenih rezultata studije, koje su upoređivale ova dva sistema.

vibration is noticeable. If the torque control is in action the dentist should stop the motor, switch the rotation to left, restart the motor and pull the file out of the root canal without pressure.

In how far the ENDOadvance system is an improvement of ENDOflash can not be assessed at the moment because results of scientific research are not available up to now.

Conclusion

The ENDOflash handpiece used with ENDOflash NiTi files is a safe system for mechanical root canal preparation. Regarding the literature the use of ENDOflash stainless steel files can not be recommended due to their unsatisfactory shaping ability. In how far the new ENDOadvance is an improvement of the ENDOflash system can not be concluded, because results of comparing studies are not published until now.

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