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Estetski intrakanalni kolčići

Esthetic Intracanal Posts

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Sažetak
Primarna zadaća intrakanalnih kolčića jest osigurati retenciju za nadogradnju zuba i omogućiti potpuno brtvljenje koronarnog dijela korijenskog kanala. Tradicionalno korišteni metalni kolčići ne ispunjavaju zahtjeve moderne dentalne medicine zbog nedostataka kao što su boja, podložnost koroziji, mehanička retencija i veliki modul elastičnosti koji može rezultirati lomom korijena. Da bi se sve to izbjeglo, počela je proizvodnja estetskih keramičkih i vlaknima ojačanih intrakanalnih kolčića. Kako se danas mnogo pozornosti posvećuje estetici, upotreba spomenutih kolčića u kombinaciji s kompozitnom / keramičkom nadogradnjom vrlo je česta u restaurativnoj dentalnoj medicini i postaje standard zahvaljujući ne samo njihovoj estetici, nego i biokompatibilnosti, dobrim fizikalno-mehaničkim svojstvima i adhezivnom vezivanju na tvrda zubna tkiva i nadogradnju. Ipak, kliničari trebaju poznavati različite vrste kolčića i pripaziti na razlike među njima kako bi pravilno odabrali i upotrijebili odgovarajuću vrstu.

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Uvod

Uspješno endodontsko liječenje zuba ne ovisi samo o kvaliteti instrumentacije (1, 2) i trodimenzionalnoj obturaciji korijenskog kanala (3, 4), nego i o kakvoći naknadnog restaurativnog tretmana (5). Gubitak više od polovine krune zuba, kao posljedica karijesa, loma ili opsežne preparacije kaviteta, zahtijeva upotrebu intrakanalnog kolčića (6) jer se na taj način osigurava uspješna restauracija (7). Tradicionalno korišteni metalni kolčići ne ispunjavaju zahtjeve moderne dentalne medicine zbog nedostataka kao što su boja, podložnost koroziji, mehanička retencija i veliki modul elastičnosti koji može rezultirati lomom korijena. Kako bi se poboljšali estetika, fizikalno-mehanička svojstva i biokompatibilnost, razvijeni su različiti estetski intrakanalni kolčići. Osim estetike, spomenuti kolčići adhezivno se vežu na tvrda zubna tkiva i na koronarnu nadogradnju, što pospješuje stvaranje tzv. monobloka kod kojeg se sile pri opterećenju raspodjeljuju podjednako na sve njegove sastavnice (8).

Cirkonij-oksidni kolčići

Potpuno keramičke restauracije postale su popularne zahvaljujući odličnoj estetici i biokompatibilnosti (9), tako da je u kliničkom radu česta uporaba bijelih i translucentnih

Introduction

A successful clinical outcome of endodontically treated teeth depends on adequate root canal instrumentation (1,2) and three-dimensional obtuartion (3,4) as well as on adequate restorative treatment performed afterwards (5). The loss of more than a half of the coronal tooth structure, caused by caries, fracture or extensive cavity preparation, mandates the use of posts (6) as they provide restorations with enhanced retention and stability (7). Traditionally used metal posts do not meet the requirements of modern dental medicine, due to disadvantages such as color, corrosion potential, non-adhesive bonding and high modulus of elasticity which can lead to root fracture. In order to enhance the esthetic aspects, physical properties and biocompatibility, a wide range of esthetic posts have been developed and become commercially available. In addition to esthetic and health benefits, they hold the capacity of adhesive bonding to tooth tissue and core build-up and that potentiates the creating of the monoblock, a gap-free single unit in which the loading stresses are evenly distributed and borne by all the monoblock components (8).

Ceramic zirconia posts

All-ceramic restorations have gained popularity due to their excellent esthetic properties and biocompatible nature (9), consequently increasing the use of white and transkolčića proizvedenih od cirkonija i ostalih keramičkih materijala. Djelomično stabilizirana cirkonij-oksidna (ZrO_2) keramika, formirana dodavanjem itrijeva oksida (Y_2O_3), pojavila se potkraj osamdesetih godina prošlog stoljeća (10, 11) i preporučuje se za proizvodnju intrakanalnih kolčića zbog svoje visoke otpornosti na lom i savijanje pa kolčići mogu izdržati velika funkcionalna opterećenja.

Osim povoljne kemijske stabilnosti, dobre estetike i fizikalnih svojstava (12), keramika izrađena od cirkonija ima i odličnu radiokontrastnost, visoku provodljivost svjetla (13) i modul elastičnosti sličan metalnom kolčiću (14). Ipak, visoki modul elastičnosti od 200 GPa uzrokuje prenošenje stresa na manje kruti dentin, što rezultira lomom zubnog korijena (15). Treba imati na umu da su cirkonijevi kolčići kruti, ali istodobno i lomljivi i ne mogu se uopće rastegnuti (9). Zbog toga je potrebno pripremiti duboku preparaciju za njihovo postavljanje, što sprječava primjenu minimalno invazivnog pristupa kada se radi o uklanjanju korijenskog dentina. Nadalje, ako zahvat kojim slučajem ne uspije i potrebno je ponovno endodontsko liječenje, spomenute snaga i otpornost postaju nedostatak zato što je cirkonijev kolčić gotovo nemoguće ukloniti iz korijenskog kanala (16).

Nekoliko je tehnika za rekonstrukciju zuba cirkonijevim kolčićem i nadogradnjom: direktna kompozitna nadogradnja, adhezivno cementirana keramička nadogradnja, tehnologija toplog tlačenja (engl. *heat-press*), jednokomadna keramička nadogradnja kolčićem.

Iako *in vitro* cirkonijevi kolčići pokazuju manju otpornost na lom kada se kombiniraju s kompozitnim nadogradnjama negoli u kombinaciji s keramičkima (14), klinički je dokazan dugoročan uspjeh cirkonijevih kolčića u kombinaciji s kompozitnim nadogradnjama (17). Kada je riječ o keramičkim nadogradnjama, cirkonijevi kolčići otporniji su na lom ako se kombiniraju s prilagođenim keramičkim krunama u odnosu na kombinaciju s individualnim keramičkim nadogradnjama (18). Ta niža vrijednost prešane individualne keramičke krune vjerojatno je rezultat promjena u unutarnjoj strukturi cirkonijeva materijala koje se pojavljuju pri procesu grijanja. Suprotno tome, retencija cirkonijeva kolčića značajno je bolja ako se kombinira s direktnom prešanom keramičkom nadogradnjom, negoli u kombinaciji s adhezivno cementiranom keramičkom krunom (19).

Cirkonijevi kolčići indicirani su kod opsežno destruiranih zuba u područjima u kojima postoje velike sile te u slučaju visokog položaja usnice i uskoga gingivnog ruba radi bolje estetike (20). Kako bi se poboljšala čvrstoća vezivanja cirkonijevih kolčića na nadogradnju i korijenski dentin, preporučuje se rabiti kompozitne cemente (21) i pripremiti površinu kolčića tijekom predtretmana od kojih je najučinkovitija kombinacija abrazije česticama Al_2O_3 i silanizacije (22).

Vlaknima ojačani kolčići

Godine 1990. predstavljena je nova vrsta intrakanalnih kolčića proizvedenih od nemetalnog materijala ojačanog karbonskim vlaknima (23). Iako su takvi kolčići lagani za upotrebu te imaju dobra mehanička svojstva, malu toksičnost i mali modul elastičnosti sličan modulu elastičnosti dentina (24), najveći im je nedostatak manjak estetike i nemogućnost

lucent posts made of zirconia and other ceramic materials for the same reasons. Partially stabilized zirconium dioxide (ZrO_2), a ceramic material, formed by adding yttrium oxide (Y_2O_3), was introduced by the end of 1980's (10,11) and recommended for the fabrication of posts because of high fracture and bending strength by which the posts can withstand functional loads.

Apart from its favorable chemical stability, good esthetic and physical properties (12), zirconia also yields excellent radiographic opacity, superior light transmission properties (13) and Young's modulus similar to that of the stainless steel alloy (14). However, the high elastic modulus of zirconia posts at 200 GPa causes stress to be transferred to the less rigid dentin, thereby resulting in root fractures (15). Furthermore, zirconia posts are stiff, but at the same time very brittle, without any ductility (9). Therefore, it is necessary to make a deep post preparation which, on the other hand, prevents the use of a minimally invasive approach when it comes to removing the dentin tissue. Furthermore, if a failure occurs and there is a need for endodontic retreatment, the reported strength becomes a significant disadvantage because it is nearly impossible to remove a zirconia post from the root canal (16).

Few techniques for zirconia post and core reconstruction are available: direct composite build-ups, adhesively luted ceramic core, and ceramic core heat-pressing and one-piece ceramic post-and-core restorations. Although *in vitro* zirconia posts exhibit lower fracture strength when used with composite cores than with ceramic cores (14), clinical long-term success appears to be excellent for a combination with composite core system (17). Within the group with ceramic cores, zirconia posts achieve higher fracture strength when used with bonded prefabricated ceramic core than with bonded custom-made ceramic core (18). This lower value of heat-pressed custom-made ceramic core over zirconia post is a result of changes in the inner structure of the zirconia material during the heating process. Conversely, the retentive strength of zirconia post with direct heat-pressed ceramic core is significantly higher than with adhesively bonded ceramic core (19).

Zirconia posts are indicated in grossly destructed tooth, areas with heavy forces and in high lip line and thin gingival tissue for achieving better esthetics (20). To improve the bond strength of zirconia post to core and root dentin, it is recommended to use resin cements (21) and do surface pretreatment of which the most effective is airborne particle abrasion using silicated Al_2O_3 particles in a combination with silanization (22).

Fiber reinforced posts

In 1990, a new nonmetallic material for the fabrication of posts based on the carbon fiber reinforcement principle was introduced.(23). Although these post are easy to manipulate and have good mechanical properties, low toxicity and low modulus of elasticity, more similar to that of dentin (24), their color and difficulty of concealment under composite skrivanja njihove boje ispod kompozitne ili keramičke nadogradnje. Kako bi se zadovoljili estetski zahtjevi, proizvedeni su kolčići ojačani staklenim i kvarcnim vlaknima. Osim dobre estetike, njihova su povoljna svojstva i visoka otpornost na udarce, prigušenje i umanjivanje vibracija, apsorpcija udaraca i velika otpornost na zamor (25).

Prefabricirani kolčići ojačani staklenim vlaknima

Translucentni intrakanalni kolčići bazirani na siliciju pojavili su se na tržištu 1992. godine. Proizvedeni su od visokoga volumnog udjela rastegnutih silaniziranih staklenih ili kvarcnih vlakana obuhvaćenih matricom od metakrilatne ili epoksi smole visokoga stupnja konverzije i visoko umrežene strukture koja veže vlakna (26). Vlakna pridonose čvrstoći i krutosti kolčića, a polimerna matrica prenosi sile na vlakna i ujedno ih štiti od vlage iz oralne šupljine (27).

BisGMA i epoksi smola uobičajeni su materijali za izradu intrakanalnih kolčića jer su kompatibilni s adhezivnim restaurativnim tehnikama. Ta svojstva omogućuju mikromehaničko i kemijsko vezivanje kolčića na korijenski dentin, što rezultira ravnomjernom raspodjelom sila duž kolčića (28). Zbog spomenutog svojstva adhezivnog vezivanja i modula elastičnosti sličnog dentinu (18 - 42 GPa) (29), biomehaničko ponašanje kolčića je bolje i otpornost na lom je veća. Raspodjela stresa i otpornost na lom ne ovise značajno o duljini i promjeru kolčića, pa njegove dimenzije manje utječu na uspjeh restauracije nego u slučaju kad se rabe metalni kolčići (30).

Silicijevi kolčići mogu biti od stakla ili kvarca. Kvarc je kristalni oblik silicija, a staklo je amorfni oblik toga elementa. Istraživanja pokazuju da su kolčići ojačani kvarcnim vlaknima radioopakniji (31) i čvršći na savijanje od kolčića ojačanih staklenim vlaknima (32), a zubi restaurirani kolčićima ojačanima kvarcnim vlaknima otporniji su na lom od onih restauriranih kolčićima ojačanima staklenim vlaknima (33).

Ipak, u dentalnoj medicini E- i S-staklena vlakna najčešće se rabe za ojačavanje kolčića. Staklena vlakna ravnomjerno se rastežu pod opterećenjem do njihove točke loma, a u slučaju prestanka djelovanja vlačne se sile vraćaju na izvornu duljinu ako je sila manja od sile loma. E-staklo (engl. *electrical application*) ima dobru vlačnu i tlačnu čvrstoću te električnu izolaciju, a i cijena mu je prihvatljiva, ali je relativno slabo otporno na zamor. S-staklo (engl. *stiff, strong*) pak ima drukčiju kemijsku strukturu koja pridonosi većoj vlačnoj čvrstoći i boljoj otpornosti na vlagu, ali je skuplje (34).

Najčešći uzrok neuspjeha u slučaju restauracije intrakanalnim kolčićem jest odvajanje kolčića od zuba (35), što se može dogoditi zbog popuštanja na spoju kolčić/cement ili cement/dentin. Vezivanje između kolčića ojačanog staklenim vlaknima i kompozitnih materijala s pomoću radikalske lančane polimerizacije teško je postići zato što je organska komponenta kolčića ojačanog vlaknima polimerna matrica koja je visoko umrežena s visokim stupnjem konverzije i malim brojem dvostrukih ugljik-ugljik veza na svojoj površini (36). Zbog ovakve inertne i nereaktivne matrice, prema posljednjim istraživanjima, predlaže se tretirati kolčić jednu minutu 24-postotnim vodikovim peroksidom kako bi se selektiv-

or all-ceramic restoration prevents them to be classified as esthetic posts. In order to meet the cosmetic requirements, posts reinforced with glass and quartz fibers were manufactured. Apart from good esthetics, their advantageous properties are also high impact resistance, attenuation and softening of vibration, shock absorption and increased fatigue resistance (25).

Prefabricated glass- and quartz-fiber posts

Translucent and tooth colored silica-based posts were introduced in 1992. They are made of high volume percentage prestretched silanizated glass- or quartz- fibers bounded by methacrylate- or epoxy-polymer matrix with high degree of conversion and highly cross-linked structure that binds the fibers (26). The fibers offer strength and stiffness, while the polymer matrix transfers loads to the fibers and also protects them from the moisture of the oral environment (27).

BisGMA and epoxy resins are commonly used as a resin based material for dental fiber posts which are therefore compatible with adhesive restoration techniques. This allows chemical and micromechanical bonding of fiber post to the root dentin that leads to a uniform stress distribution (28). Due to this fact and the similarity in elastic modulus with dentine (18-42 GPa) (29), biomechanical performance is better and fracture resistance increases. Additionally, stress distribution and fracture resistance of a silica-based post are not significantly influenced by post length and diameter, hence the restoration technique is less sensitive to post dimension in this case than when stainless steel posts are used (30).

The silica-based fibers can be made of glass or quartz. Quartz is a crystalline form of silica, whereas glass is monocrystalline. It has been found that that the quartz fiber posts are more radiopaque (31), have a higher flexural strength than the glass fiber posts (32) and that the teeth restored with quartz fiber posts have higher fracture strength than those with glass fiber posts (33).

However, in dentistry, E- and S-glass fibers have become the most commonly used reinforcing fibers. Glass fibers stretch uniformly under stress to their breaking point, and on removal of the tensile load short of breaking point, the fiber returns to its original length. E (electrical application)-glass has good tensile and compressive strength, as well as electrical insulation and rather low cost, but relatively poor fatigue resistance, while S (stiff, strong)-glass has a different chemical composition, giving higher tensile strength and better tensile strength and moisture tolerance, but is rather expensive (34).

The most frequent failure of fiber post restoration is post debonding (35) which can happen on the post/cement or cement/dentine interface. The bond between glass fiber post and composite substrates is difficult to achieve by means of free radical polymerization bonding because the organic component of fiber post is a polymer matrix that is highly cross-linked with a high degree of conversion and a small number of carbon-carbon double bonds on the surface (36). Because of this inert and nonreactive polymer matrix, recent research suggest to treat the post with H_2O_2 (24%) for 1 minute to selectively dissolve the polymer matrix and expose the glass fibers, allowing micromechanical interlocking of adheno otopila polimerna matrica i izložila staklena vlakna, čime se omogućuje mikromehaničko vezivanje adheziva/cementa na kolčić (37). H_2O_2 često se upotrebljava u dentalnoj praksi, uglavnom za izbjeljivanje zuba, te je siguran i lagan za korištenje jer ne utječe na kolčiće ojačane vlaknima, tj. ne oštećuje ih. Nadalje, nakon tretmana vodikovim peroksidom slijedi silanizacija kolčića kako bi se izložena vlakna mogla kemijski vezati s adhezivom/cementom (38). Za cementiranje kolčića ojačanih staklenim vlaknima najbolja su opcija dvostruko polimerizirajući materijali (39).

Iako u kliničkim istraživanjima nije bilo značajnih razlika u otpornosti na lom između metalnih kolčića i onih ojačanih staklenim vlaknima (40), ovi drugi često su prvi izbor doktora dentalne medicine ne samo zbog zadovoljavajuće estetike, biokompatibilnosti, čvrstoće savijanja, otpornosti na zamor, povoljnog modula elastičnosti i čvrstoće vezivanja vlakana na kompozitne materijale, nego i zbog pristupačne cijene, jednostavnog rukovanja, moguće jednoposjetne terapije te mogućnosti njihova uklanjanja iz korijenskog kanala. No kada se zub restaurira prefabriciranim kolčićima ojačanima staklenim vlaknima, treba uzeti u obzir da se indikacija odnosi samo na zube s dobro sačuvanom strukturom korijena (20). Naime, takvi kolčići zahtijevaju preparaciju korijenskog kanala koja odgovara njihovu obliku i dimenzijama, što uzrokuje gubitak dentina i čini korijen zuba dodatno osjetljivim na lom (41). Ujedno, pri upotrebi prilagođenog kolčića ojačanog vlaknima slobodan prostor širokog koronarnog dijela korijenskog kanala ostaje ispunjen samo cementom koji se tijekom polimerizacije kontrahira, što može uzrokovati odvajanje cementa od dentina, a to posljedično može rezultirati mikropropuštanjem duž kolčića i konačno neuspjehom restauracije.

Individualni kolčići ojačani staklenim vlaknima

Početkom 21. stoljeća proizvedeni su individualni kolčići ojačani staklenim vlaknima (29) kako bi se uklonili nedostatci i poboljšale prednosti prilagođenih kolčića ojačanih staklenim vlaknima. Takvi kolčići izrađeni su od jednosmjernih, silaniziranih E-staklenih vlakana impregniranih kombinacijom dvaju nepolimeriziranih polimera – PMMA kao linearnom fazom i poli-Bis-GMA kao umreženom fazom, koji formiraju poluinterpenetrirajuću polimernu mrežu, tj. matricu (engl. *semi-IPN*). PMMA-lanci, molekularne mase 220 KD-a plastificiraju umreženu matricu Bis-GMA i tako smanjuju stres koji se stvara na dodirnim površinama vlakana i matrice pri savijanju (29). Zahvaljujući nepolimeriziranoj poluinterpenetrirajućoj mreži, monomeri adhezivnih smola i cemenata mogu difundirati u linearnu polimernu fazu i polimerizacijom potaknuti interdifuzijsko vezivanje i tzv. sekundarnu poluinterpenetrirajuću mrežnu strukturu (42) koja pridonosi boljem prijenosu sila s koronarne nadogradnje na korijen zuba. Smolasti materijali prikladni za otapanje IPN-matrice, tj. lineranog polimera, sadržavaju monomere poput Bis-GMA, TEGDMA ili HEMA (36) i zapravo su većina onih kojima se koristimo u restaurativnoj dentalnoj medicini.

Budući da su nepolimerizirani, IPN-kolčići mogu se vrlo lagano prilagoditi obliku korijenskog kanala, smanjujući tako broj šupljina, a i mogućnost da se kolčić odcementira (43). Koncept uporabe individualnih kolčića ojačanih vla-

sive/cement with the post (37). H_2O_2 is frequently used in dental practice, mainly for dental bleaching. It is easy and safe to use and does not affect the integrity of the fiber posts. Furthermore, after the H_2O_2 treatment, the exposed fibers become available to chemically bond to the adhesive/cement through the silane agent (38). For glass fiber post cementation light-irradiated dual-cure materials provide the most reliable option (39).

Although clinical studies have not showed significant difference for root fracture incidence between metal and glass fiber post (40), the latter are often first clinician's choice, not only because of their sufficient esthetics, biocompatibility, flexural and fatigue strength, favorable elastic modulus and bond strength of fibers to composite substrates, but also because they are cheap, easy to handle and require one-visit therapy. Besides, they are easily removed if necessary. However, when restoring teeth with prefabricated glass fiber post, it should be considered that indication applies only to teeth with well conserved radicular structure (20) because they require preparation of the root canal to fit the shape of the post, which causes the loss of dentin and makes the root more vulnerable to root fracture (41). Also, by using the prefabricated FRC posts, the free space of a larger coronal root canal opening remains filled only with cement and due to changes during polymerization shrinkage, this may cause detachment of the luting resin from the dentin, consequently leading to microleakage along the post space and, also, to the failure of the post.

Individually formed glass fiber posts

In the early 2000s, individually formed glass fiber reinforced posts were introduced (29) to eliminate the shortcomings and improve the advantages of the prefabricated glass reinforced posts. They are made of unidirectional, silanated E-glass fibers impregnated with a combination of two nonpolymerized polymers, PMMA as a linear phase and poly Bis-GMA as the cross-linked phase that form semi-interpenetrating polymer network (semi-IPN). PMMA chains, with molecular weight of 220 KD, plasticize the cross-linked Bis-GMA based matrix and thus reduce the stress formation in the fiber-matrix interface during deflection (29). Because of the non-polymerized semi-IPN, the monomers of adhesive resins and cements can diffuse into the linear polymer phase and by polymerization, form interdiffusion bonding and so-called secondary semi-IPN structure (42) that contributes to the better load transfer from the core to the root. Resin substrates suitable for dissolving the IPN matrix, and linear polymer are the ones containing monomers such as Bis-GMA, TEGDMA or HEMA (36) and belong to those that are most commonly used in restorative dentistry.

Since they are not polymerized, the IPN posts can be easily adapted to the shape of the root canal, thereby possibly reducing the number of voids and potentially reducing the possibility of post decementation (43). The concept of using individually formed FRC posts is based on minimizing the knima temelji se na smanjenju potrebne preparacije u dubljim dijelovima korijenskog kanala i mogućnosti dodavanja veće količine vlaknima ojačanog materijala u koronarnom dijelu korijenskog kanala. Zato ovakav koncept štedi korijenski dentin, umanjuje stres u apikalnim dijelovima kolčića i omogućuje formiranje krutog i na lom otpornog kolčića s velikim koronarnim promjerom, što stvara čvrstu potporu za koronarnu nadogradnju (41). Dodatno, koronarni dio kolčića može se saviti na željenu angulaciju i tako prilagoditi kako bi se zadovoljile potrebe tijekom restauracije zubne krune. Individualizirani kolčići ojačani staklenim vlaknima mogu se upotrijebiti i u zavijenim i u ovalnim korijenskim kanalima, ali i u vrlo širokim kanalima u koje se tehnikom lateralne kondenzacije može postaviti više kolčića različitih dužina i promjera.

Iako individualni kolčići ojačani staklenim vlaknima, u usporedbi s prilagođenim kolčićima, imaju veću otpornost na savijanje (29) i lom (44) te veću čvrstoću vezivanja bez adhezivnog popuštanja na spoju kolčić-cement (43,45), za neiskusnog terapeuta složeniji su za rad i traže više vremena zbog ljepljivosti nepolimerizirane matrice i sklonosti jednosmjernih vlakana razdvajanju.

Polietilenski kolčići

Za postendodontsku restauraciju mogu se također rabiti polietilenski intrakanalni kolčići (46), komercijalno dostupni još od 1992. godine i proizvedeni od plazmom tretiranih polietilenskih vlakana ultravisoke molekularne mase upletenih u trodimenzionalnu strukturu. Zahvaljujući specifičnom uzorku pletenih niti, osigurano je čvršće mehaničko vezivanje, a zbog predtretmana hladnom plazmom površinska napetost vlakana je smanjena kako bi se omogućila dobra kemijska veza sa smolastim materijalima (47).

Prema tvrdnjama proizvođača, osim što imaju izvrsna svojstva u translucenciji, polietilenska vlakna uvelike premašuju točku loma staklenih vlakana i toliko su tvrda da su potrebne specijalne škarice za njihovo rezanje. Za razliku od labavo pletenih ili u snopovima postavljenih jednosmjernih staklenih vlakana, ova se vlakna ne razdvajaju i ne raspadaju pri rukovanju i prilagodbi zato što su niti spletene u gustu mrežu pa sprječavaju bilo kakvo pomicanje vlakana (48). Zbog takvih svojstava polietilenska vlakna mogu se saviti pod oštrim kutem i plesti tako da tvore čvrst i uzak spoj među nitima. Polietilenska vlakna ultravisoke molekularne mase imaju i visok koeficijent elastičnosti te visoku otpornost na rastezanje (49), što im omogućuje da se prilagode obliku korijenskog kanala i pravilno kondenziraju, povećavajući promjer individualnog intrakanalnog kolčića i smanjujući debljinu cementa te posljedično njegovo polimerizacijsko skupljanje. Kako se vlakna prilagođavaju obliku korijenskog kanala, nije ga potrebno proširivati, pa je postojeća čvrstoća zuba sačuvana, a mogućnost potencijalne perforacije korijena eliminirana. U usporedbi s drugim kolčićima ojačanima vlaknima (uključujući i individualne staklenim vlaknima ojačane kolčiće), individualni polietilenski kolčići učvršćeni dvostruko stvrdnjavajućim cementom pokazuju najmanju količinu mikropropuštanja u previše proširenim korijenskim kanalima (50) koji zapravo i jesu indikacija za njihovo korištenje.

preparation in the deeper parts of the root canal thus allowing addition of higher quantity of FRC material to the coronal root canal opening of the tooth. In this way, this concept saves the dentin, minimizes stress at the apical parts of the post and enables stiff and fracture resistant post with larger diameter to form strong support for the core (41). Additionally, the coronal part of the IPN-post can be bent to the desired angulation and adapted to meet the requirements of the crown restoration. Individually formed glass fiber posts can also be used in curved and oval root canals as well as in very large canals, where several posts of different lengths and diameters can be placed in the same canal by means of lateral condensation.

Although individually formed glass fiber posts, in a comparison with prefabricated glass fiber posts, show higher flexural strength (29), higher fracture resistance (44), higher bond strength without adhesive (post-cement interface) failure (43,45) they are more complicated to use for an inexperienced clinician due to a highly sticky nature of a non-polymerized matrix and fibers tendency to separation.

Polyethylene fiber posts

For postendodontic restoration, polyethylene fiber posts can be used (46). This reinforcement material, that has been commercially available since 1992, is composed of plasma treated ultra-high molecular weight polyethylene fibers woven into three dimensional structure, leno wave or triaxial braid. Due to special patterns of cross-linked threads, a higher mechanical interlocking is provided. Also, the fiber's superficial tension is reduced due to cold gas plasma pretreatment in order to ensure good chemical bond to resin materials (47).

According to the manufacturer, apart from having excellent properties in translucency, polyethylene fibers exceed the breaking point of fiberglass and are so tough that special scissors are required to cut them. In addition, unlike loosely braided or bundles of unidirectional fibers, these fibers do not spread or fall apart when manipulated because the dense network of locked-stitched threads prevents the fibers from shifting during manipulation and adaptation before polymerization (48). Because of these characteristics, polyethylene fibers can be bent to sharp angles and woven to make tight mechanical inter-locking from one thread to another. Also, these ultra-high molecular weight polyethylene fibers have a high elasticity coefficient and a high resistance to stretch, distortion and traction (49) that allows them to adapt closely to the contours of the root canal and to properly condense, increasing the content of individually made endodontic post thus decreasing the luting-agent thickness and consequently its polymerization shrinkage. Since the fibers adapt to the root canal, the canal enlargement is not required, hence the natural strength of the tooth is preserved and a possibility of the root perforation is eliminated. In a comparison with other fiber reinforced posts (including the individually formed glass fiber reinforced post), an individually shaped polyethylene post cemented with dual-cure resin cement shows the least amount of microleakage in overflared root canals (50).

Za razliku od neprekidnih jednosmjernih staklenih vlakana koja kompozitu daju najvišu čvrstoću i krutost samo u smjeru orijentacije vlakana, polietilenska vlakna ojačavaju polimer u svim smjerovima, pa su im mehanička svojstva izotropna (51). Arhitektura pletenih vlakana poboljšava otpornost na lom, što je također vidljivo pri stvaranju pukotina izazvanih opterećenjem. Pukotina se zaustavlja na čvoru vlakna čime se sprječava njezino daljnje širenje s restauracije na zub i održava se pojačanje koje tvore polietilenska vlakna (52).

Dokazano je da polietilenska vlakna osiguravaju dovoljnu retenciju potrebnu za klinički uspjeh sustava koji čine kolčić i nadogradnja (53) te dovoljnu otpornost na lom s povećanom incidencijom lomova koji se mogu popraviti u strukturno kompromitiranim korijenskim kanalima (54). No unatoč spomenutim odličnim svojstvima, visoka cijena polietilenskih vlakana ograničava njihovu uporabu u svakodnevnoj praksi.

Zaključak

Primarna funkcija intrakanalnog kolčića jest osigurati retenciju za nadogradnju i omogućiti potpuno brtvljenje koronarnog dijela korijenskog kanala. Stoga kolčić mora čvrsto prianjati na dentin i koronarnu nadogradnju. Osim toga, treba biti dovoljno otporan na lom kako bi izdržao opterećenja, ali mora imati i modul elastičnosti sličan dentinu da se omogući ujednačena raspodjela sila i spriječi lom korijena zuba.

Kako se danas velika pozornost posvećuje estetici, uporaba estetskih intrakanalnih kolčića s kompozitnom / keramičkom nadogradnjom vrlo je česta u restaurativnoj dentalnoj medicini i zapravo postaje standard. To se događa zahvaljujući, ne samo njihovoj estetici, nego i biokompatibilnosti te dobrim fizičko-mehaničkim svojstvima.

Uspješna restauracija endodontski liječenog zuba izazov je za doktora dentalne medicine koji prije postavljanja kolčića treba analizirati čimbenike poput preostale količine krune zuba, veličine i konfiguracije korijenskog kanala, položaja zuba, funkcionalnih zahtjeva i okluzije.

Kliničar treba poznavati razlike između intrakanalnih kolčića kako bi ih u određenoj situaciji pravilno odabrao i upotrijebio.

Sukob interesa

Nije bilo sukoba interesa.

Unlike the continuous unidirectional fibers that give the highest strength and stiffness for the composite only in the direction of the fiber orientation, polyethylene fibers reinforce the polymer in all direction so that the mechanical properties are isotropic (51). Woven fiber architecture enhances fracture resistance which is also evident in the case of cracks induced by load. The crack stops at the node of the leno-lock-stitch weave, thereby preventing the crack propagation from the restoration to the tooth and helping maintain the integrity of the fiber reinforcement (52).

It has been shown that polyethylene-reinforced resin provides sufficient retention required for clinical success of a post and core system (53) and adequate fracture resistance with increased incidence of repairable fractures in structurally compromised canals (54). However, high price of polyethylene fibers limits their use in daily practice despite the abovementioned excellent characteristics.

Conclusion

The primary function of endodontic post is to provide retention for the core and enable full sealing of coronal portion of the root canal. Therefore, it should bond firmly to the root dentin and buildup core. Additionally, intracanal post should have sufficient fracture strength to withstand the loads, but elastic modulus similar to that of dentin to enable more uniform stress distribution and to prevent root fractures.

Since much attention is given to esthetics, using esthetic posts with composite/ceramic cores has become very common in restorative dentistry. In fact, this is becoming a standard because these posts esthetically pleasing, biocompatible and have good physical properties.

The successful restoration of an endodontically treated tooth is an ongoing challenge for a dentist. Before inserting a post, factors such as remaining amount of coronal tissue, root canal size and configuration, tooth position, functional requirements and occlusion need to be analyzed.

The clinician should be aware of the differences between different intracanal posts in order to select and use the most appropriate post system in each specific situation.

Conflict of interes

The authors report no conflicts of interest.

Abstract
The primary function of an endodontic post is to provide retention for the core and enable full sealing of the coronal portion of the root canal. Traditionally used metal posts do not meet the requirements of modern dental medicine due to some fairly significant drawbacks such as color, corrosion potential, non-adhesive bonding and high modulus of elasticity which can lead to root fracture. Recently, esthetic ceramic and fiber reinforced posts have been manufactured in order to avoid such imperfections. Since much attention has been devoted to the esthetic aspects of dental medicine, the use of these posts with composite/ceramic cores is very common in restorative dentistry and it is actually becoming a standard. This is due to the fact that, apart from being an esthetically pleasing material, they are also biocompatible, have good physical properties and the capacity of adhesive bonding to tooth tissue and core buildup. Nonetheless, a good clinician should know how to spot the difference between them in order to select and use the appropriate post system in each specific situation.

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Key words
Post and Core Technique; Zirconium Oxide; fiberglass reinforced polymers; Polyethylene

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