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NEMETALNI *FIBER-GLASS* KOČIĆI U STOMATOLOŠKOJ PROTETICI

THE NONMETALLIC *FIBER-GLASS* POSTS IN PROSTHETIC DENTISTRY

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Kratak sadržaj

Uvod. FRC (fiber-glass reinforced composite) kočići sa ojačanim kompozitnim vlaknima predstavljeni su kao alternativa mnogim konvencionalnim materijalima. Endodontski tretirani zubi pokazuju povećan rizik biomehaničke slabosti za razliku od vitalnih zuba. Izbor adekvatne restauracije za endodontski tretirane zube ogleda se u snazi i estetici restaurativnih materijala.

Osnovni cilj ovog rada je da se predstavi primena najnovijih bezmetalnih sistema u restaurativnoj stomatologiji. Fizičke karakteristike predstavljene od strane proizvođača (Ivoclar Vivadent, Schaan, Liechtenstein) ukazuju na odlične rezultate koji se poistovećuju sa osobinama zubnih struktura u pogledu snage savijanja, modula elastičnosti, apsorpcije vode i uočljivosti na rendgen snimcima. Upotreba ovih nemetalnih kočića je relativno laka, brza, bezbedna i pouzdana. Istraživanja mnogih autora ukazuju na odlične rezultate novih nemetalnih sistema nadogradnje. Imaju fizičke osobine slične dentinu, postižu maksimalnu retenciju sa malo uklanjanja dentina iz kanala korena, prenose funkcionalne pritiske duž čitave površine korena, kompatibilni su sa materijalima za izradu kruničnog dela nadogradnje, ispunjavaju visokozahtevne estetske norme, vrše minimalan pritisak tokom plasiranja i cementiranja, imaju otpornost na dislokaciju, omogućuju dobru retenciju kruničnog dela nadogradnje, poseduju mogućnost lake revizije, laki su za upotrebu, bezbedni i pouzdani, i imaju razumnu cenu troškova.

Zaključak. Nemetalni fiber-glass kočići su umnogome doprineli razvoju novih sistema nadogradnji i poboljšali kvalitet protetskog tretmana. Poređenja vršena sa dosadašnjim konvencionalnim materijalima i sistemima pokazuju značajnu prednost u korist novih tehnoloških dostignuća.

Ključne reči: *dentalni materijali, kočići kanala korena, fiber-glass kočići, adhesivni sistemi*

Abstract

Introduction. FRC (fiber-glass reinforced composite) posts with reinforced composite fibers are introduced as an alternative for many conventional materials. Endodontically treated teeth are known to present a higher risk of biomechanical failure than vital teeth. The choice of an appropriate restoration for endodontically treated teeth is guided by strength and esthetics.

The aim of this study is to present the use of new item nonmetallic systems in restaurative dentistry. Physical characteristics given by manufacturer (Ivoclar Vivadent, Schaan, Liechtenstein), show exellent results, are identified with tooth structure in regard of flexure strength, module elasticity, water absorbtion and clear radiopacity. The use of nonmetallic posts is easy, fast, safe and reliable.The research of several authors has shown exellent results of newer nonmetallic systems. They have the following features: physical properties similar to dentin, maximum retention with little removal of dentin from the root canal, distribution of functional stress even along the root surface, material compatibility with core, high esthetic qualities, minimal stress during placement and cementation, resistance to displacement, good core retention, easy retrievability, ease of use, safety and reliability, and reasonable cost.

Conclusion. Nonmetallic fiber-glass posts contributed greatly into the development of new post and core systems and improved the quality of prosthetic treatment. In comparison with former conventional materials and post and core systems, FRC posts demonstrate significant preference for new technological accomplishments.

Key words: *Dental materials, Root canal posts, Fiber glass posts, Adhesive systems*

Uvod

Endodontski tretirani zubi pokazuju povećan rizik biomehaničke slabosti za razliku od vitalnih zuba. Kočići su generalno indikovani da

Introduction

Endodontically treated teeth are known to present a higher risk of biomechanical failure than vital teeth. Posts are generally indicated to

nadoknade izgubljeni deo zubnog tkiva i kod depulpiranih zuba.[1] Izbor adekvatne restauracije za endodontski tretirane zube ogleda se u snazi i estetici restaurativnih materijala.

Na osnovu dosadašnjih istraživanja, upotreba kočića je neophodna u slučajevima kada preostalo zubno tkivo u cervikalnoj regiji nije u stanju da pruži adekvatnu podršku i retenciju restauraciji.[1] Činjenice na koje svakako treba obratiti pažnju su:

- Zub biva oslabljen posle endodontskog tretmana.
- Preparacija kanala korena zuba za kočić takođe slabi zub,
- Funkcija kočića je da obezbedi postojanu vezu između protetske nadoknade i preostale zubne supstance.[2]
- Kriterijumi za restauraciju destruiranih zuba su postojanje tvrdog zubnog tkiva kao i opterećenje suprastrukture. Ukoliko ima uslova za retenciju nadogradnje na preostalom zubnom tkivu opšta preporuka je ne koristiti kočić.[3]

Da bi se postigli optimalni rezultati, materijali upotrebljeni za kočiće bi trebali da imaju slične fizičke osobine dentina, da mogu da se fiksiraju za zubna tkiva i da budu biokompatibilni u oralnoj sredini.[4] Takođe treba da imaju ulogu u absorbciji šoka prenoseći samo ograničeno opterećenje na preostale zubne strukture.[5] Na žalost, materijali koji se koriste za kočiće i krunični deo nadogradnje, kao i fiksirajuće komponente, imaju različite fizičke osobine od dentina i pokazuju fundamentalnu razliku zamora materijala.[6]

Konvencionalne metode nadogradnje

Tradicionalno, kočići su se izrađivali od metalnih legura. Nekoliko studija[9] se bavilo ispitivanjem izrade nadogradnje od različitih legura i drugih materijala različite čvrstoće i ukazali da rigidni materijali pružaju otpor jačim silama bez savijanja. Stoga, postoji potencijalna opasnost od korišćenja materijala visoke čvrstoće u izradi kočića.

Jedan od glavnih razloga koji je motivisao istraživače da pronađu alternativna rešenja za metalne kočiće je prevencija frakture korena, koji je bio glavni uzrok neuspeha ovim načinom restauracije. Ustanovljeno je da rigidnost me-

restore missing tooth structure as well as with pulpless teeth.[1] The choice of an appropriate restoration for endodontically treated teeth is guided by strength and esthetics.

Based on the current research, it can be seen that the placement of a post should be considered only when the remaining cervical tooth tissue can no longer provide adequate support and retention for a restoration.[1] Certainly, the very important facts are:

- The tooth becomes weakened after endodontical treatment.
- Root canal preparation for post also weakens the tooth.
- The main function of posts is to provide stability between the core and the rest of tooth supstance.[2]
- Criteria for damaged teeth restauration are hard tooth tissue existence and suprastructure load, too. If there are any conditions for core retention on the rest tooth tissue, the general recommendation is not to use a post.[3]

To achieve optimum results, the material used for the post should have physical properties similar to that of dentin, be bonded to the tooth structure, and be biocompatible in the oral environment.[4] It should also act as a shock absorber by transmitting only limited stress to the residual tooth structure.[5] Unfortunately, the materials used for post and cores, as well as luting agents, have distinct physical properties different from dentin and exhibit fundamentally different fatigue behavior.[6]

Conventional methods in post and core systems

Traditionally, posts were made of metal alloys. Recently, nonmetallic posts have been introduced. Several studies[9] have examined post and cores made of various alloys and other materials with different rigidity and demonstrated that rigid materials resisted greater forces without distortion. Therefore, there may be a potential danger in using high rigid posts.

One of the major reasons that motivated researchers to find alternative solutions to metal posts was to prevent root fracture, which once was the main cause of failure with this type of

talnih fabričkih kočića i osobine livenih metalnih nadogradnji značajno utiču na povećanje rizika frakture korena.[7–9] Nedavna istraživanja su ukazala na činjenice da rigidnost (krutost) kočića mora biti ista ili približna zubnim strukturama kako bi se okluzalne sile distribuirale čitavom dužinom korena.[10-12]

Drugi, veoma bitan razlog, koji se ne sme zanemariti je estetika. Metalni sistemi mogu imati vrlo negativan efekat na estetske kvalitete sve više korišćenih bezmetalnih zubnih nadoknada.[13-17] Biokompatibilnost je još jedan od faktora koji ukazuje na značajnost upotrebe bezmetalnih sistema.

Nedavno predstavljeni karbonski vlaknasti kočići treba da imaju mehaničke osobine koje su približne osobinama zuba.[18,19] Prisustvo paralelnih vlakana u osnovnoj masi karbonskih vlaknastih kočića omogućilo je apsorpciju i razlaganje sila opterećenja.[18,19] U vitro studijama[18,20], međutim, pokazalo se da su karbon vlaknasti kočići slabiji u poređenju sa metalnim kočićima podvrgnuti dejstvu sila koje vladaju u usnoj duplji. Kočići od karbonskih i grafitnih vlakana su crne boje što je glavni estetski nedostatak.

Cirkonijum keramički kočići koji su danas u upotrebi imaju visok modul elasticiteta, pa su stoga sile preusmerene sa kočića direktno na zubni međusklop bez apsorpcije stresa.

Krući keramički kočić može prouzrokovati frakture korena pre u poređenju sa karbonskim vlaknastim kočićima. Asmussen i saradnici[19] su demonstrirali da su frakture endodontski restauriranih zuba češće kod keramičkih nego li karbon-vlaknastih kočića.

Savremene metode nadogradnje

FRC (fiber-reinforced composite) kočići sa ojačanim kompozitnim vlaknima su predstavljeni kao alternativa mnogim konvencionalnim materijalima. Nadoknade karbonskim/grafitnim vlaknastim kočićima napravile su pomak u pogledu smanjenja pojave fraktura u odnosu na industrijske titanijumske ili livene metalne kočića. Istraživanja koja su u toku najavljuju takođe dobre rezultate.

restoration. It has been reported that the rigidity of metal prefabricated posts and the shape and rigidity of cast gold post and cores may pose a risk and cause root fracture.[7–9] Recent reports suggest that the rigidity of the post should be equal or close to that of the tooth to distribute the occlusal forces even along the length of the root.[10-12]

The second very important reason, which should not be ignored, is esthetic. Metal post-and-core foundations can negatively affect the esthetic qualities of all-ceramic restorations by altering light transmission.[13-17] Biocompatibility is one of the additional factors which points to the importance of the use of non-metalic systems.

Recently introduced carbon fiber posts are purported to have mechanical properties that closely match those of the tooth.[18, 19] The presence of the parallel fibers in the resin of carbon fiber posts enable them to absorb and dissipate stresses.[18, 19] In vitro studies,[18, 20] however, it has been demonstrated that carbon fiber posts have inferior strength matched with metal posts when subjected to forces simulating those in the oral cavity. The nonmetallic carbon fiber and graphite posts are black and that is their main esthetic deficiency.

Zirconium ceramic, which is presently used for posts, has a high modulus of elasticity, and therefore the forces are assumed to be transmitted directly from the post to the tooth interface without shock absorption.

The stiffer ceramic post may cause more root fractures compared with the carbon fiber post. Asmussen et al[19] have demonstrated that fracture of endodontically restored teeth is less extensive with carbon fiber posts than with ceramic posts.

Contemporary methods with post and core systems

Fiber-reinforced composite (FRC) root canal posts have been introduced as an alternative to more conventional materials. The biomechanical properties of FRC posts have been reported to be close to those of dentin. Teeth restored with e.g. carbon/graphite fiber posts are found to resist fracture propagation better than teeth restored with prefabricated titanium posts or cast metal posts. Ongoing clinical trials are also suggesting good results.

Struktura FRC kočića

Kompozitni kočići ojačani staklenim vlaknima (fiber-reinforced composite posts), FRC-kočići su sastavljeni od usmerenih staklenih vlakana koja su fiksirana u smoli - matriksu. Polimeri matriksa su najčešće „*epoxy polimeri*“ sa visokim stepenom promene monomera i gusto isprepletanom strukturom. Mogu se izrađivati od različitih vrsta stakla. [a)]E-glass je najčešće korišćena vrsta staklenih vlakana koja se dobija mešanjem silicijum dioksida (SiO_2), kalcijum oksida (CaO), bor oksida (B_2O_3), aluminijum oksida (Al_2O_3) i nekih drugih oksida alkalnih metala. [b)]S-glass je takođe amorfna mešavina ali se razlikuje u sastavu. [c)]Quartz je čist silicijum dioksid u kristalnoj formi, inertan materijal sa malim koeficijentom termalne ekspanzije [d)](CTE).[23,24]

E-glass je najčešće korišćena vrsta stakla koja je takođe i najekonomičnija, jer pruža zadovoljavajući kvalitet po vrlo niskoj ceni. Kontinuirana usmerena E-glass vlakna i multifazni polimerni matriks pokazali su bolju vezu između FRC materijala i kompozitnih smola.[25] Ova činjenica je bazirana na polumeđupenetrantnim uskim vezama (semi-IPN) polimernog matriksa ovakvih FRC materijala. U ovakvoj jednoj sredini, razlikujemo dve faze i to linearnu polimernu fazu i ukrštenu (isprepletenu) fazu. Monomeri adhezivnih smola i cementa difunduju u linearnu polimernu fazu i u polimerizacionoj formi ostvare vezivanje.[26,27] Fiberglass kočići su napravljeni od staklastih vlakana, neorganskog punioca i smole matriksa[e)]. 60% Vol zauzimaju staklasta vlakna usmerena čitavom dužinom uzdužne ose kočića.

a) (E-glass) – (Electrical glass), dobio naziv po hemijskoj strukturi koja ga čini odličnim izolatorom.

b) (S-glass) – (high-strength glass), visoko-otporna staklena vlakna.

c) (Quartz) – kvarc- čist SiO_2

d) (CTE) – koeficijent širenja materijala na određenoj temperaturi.

e) polymer matrix triethylene-glycol-dimethacrylates (TEGDMA) i urethane-dimethacrylates (UDMA) monomera, u kombinaciji sa visoko disperzovanim silicon dioxid-om.

Structure of the FRC posts

FRC posts contain a high volume percentage of continuous reinforcing fibers embedded in a polymer matrix, which keeps the fibers together. Matrix polymers are commonly epoxy polymers with a high degree of conversion and a high cross-linked structure. Glass fiber posts can be made of different types of glasses. Electrical glass [a)]E-glass is the most commonly used glass type in which the amorphous phase is a mixture of SiO_2, CaO, B_2O_3, Al_2O_3 and some other oxides of alkali metals. [b)]S-glass-high-strength glass is also amorphous but differs in composition. Additionally, glass fiber posts can also be made of quartz-fibers.[c)]Quartz is pure silica in crystallized form. It is an inert material with a low coefficient of thermal expansion [d)](CTE).[23, 24]

Being the most efficient, because of its satisfactory quality at rather low prices, E-glass is most commonly used type of glass. With a novel FRC material, which consists of continuous unidirectional E-glass fibres and a multiphase polymer matrix, studies have shown increased bond strength between FRC material and composite resin compared to prefabricated FRC material or other cross-linked composite resin. This was based on the semiinterpenetrating polymer network (semi-IPN) polymer matrix of this FRC material. In the semi-IPN structure, there are both linear polymer phases and cross-linked polymer phases. The monomers of the adhesive resins and cements can diffuse into the linear polymer phase, and by polymerization form an interdiffusion bonding.[26, 27] Glass-fiber posts are composed of glass fibers, inorganic filler, and a resin matrix [e)]. Fiber content is approximately 60%Vol of the post with unidirectional orientation of fibres along the longitudinal axis of the post.

a) (E-glass) – (Electrical glass), exellent insulator

b) (S-glass) – high-strength glass

c) (Quartz) – pure SiO_2

d) (CTE) – coefficient of thermal expansion.

e) polymer matrix triethylene-glycol-dimethacrylates (TEGDMA) and urethane-dimethacrylates (UDMA) monomera, in combination with high dispersed silicon dioxid.

Oblik FRC kočića

Fiber–glass kočići se proizvode u više oblika. Na tržištu se mogu naći cilindrični, dvostepeno cilindrični, cilindrično konični i konični. (sl. 1) Uglavnom su u upotrebi poslednja dva navedena. Prema tehničkim podacima jednog od proizvođača ove vrste kočića Ivoclar Vivadent, Schaan, Liechtenstein, kočići se izrađuju u dve veličine, u zavisnosti od morfologije korena i kanala korena.(sl. 2) Dužine do 20 mm, promera u apikalnom delu od 0.8-1.0 mm, u koronarnom delu od 1.5-2.0 mm. U kompletu sa kočićima se isporučuju odgovarajući proširivači koji im obezbeđuju adekvatan prostor u kanalu korena. Oni ujedno služe i za lako uklanjanje iz kanala korena ukoliko je revizija endodonskog tretmana potrebna, što nije slučaj sa metalnim ili keramičkim kočićima gde je ovaj proces otežan ili nemoguć.

FRC posts - shape

The available post designs can be classified according to their shapes and surface characteristics. They may be parallel, tapered, or parallel-and-tapered combination. (Figure 1) The last two mentioned are mostly in use. According to the technical characteristics one of the manufacturers of this type of posts -Ivoclar Vivadent, Schaan, Liechtenstein, posts are made in two sizes, depending on the morphology of the root and the root canal. (Figure 2) Post length is 20 mm, 0.8-1.0 mm in appical and 1.5-2.0 mm in coronal diameter. Appropriate reamers which provide adequate space in root canal are in set with posts. Reamers also serve for easy removing the posts out of the root canal if revision of endodontic treatment is necessary, unfortunately, the retrievability of a metal and ceramic posts have been found to be more difficult.

Slika 1. Cilindrični, dvostepeno cilindrični

Figure 1.Cylindrical, two-step cylindrical, cylindrical conical, conical posts

Size	Diametar apical [D_1]	Lenght coronal [D_2]	
	[L]		
❶	0.8mm	1.5mm 15mm	20mm
❷	1.0m	2.0mm 18mm	20mm

Slika 2. Dimenzije FRC Postec Plus

Figure 2. Dimension of FRC Postec Plus cilindrično konični i konični kočići

Fizičke karakteristike

Fizičke karakteristike ukazuju na odlične rezultate, tj. poistovećuju se sa osobinama zub-

Physical characteristics

The biomechanical properties of FRC posts have been reported to be close to those of dentin

nih struktura i u pogledu snage savijanja, modula elastičnosti, apsorpcije vode i uočljivosti na rendgen snimcima itd.

Da bi se postigli optimalni rezultati, materijali koji se koriste kod endodontski tretiranih zuba moraju imati fizičke i mehaničke osobine slične dentinu, treba da ostvaruju dobru vezu sa zubnim strukturama i da budu biokompatibilni u oralnoj sredini.[21] Kočići ove vrste daju odlične mehaničke osobine, otpornost na koroziju i dejstvo sila koje dovode do zamora materijala.

Anizotropna priroda* usmerenih vlakana kočića rezultuje različitim modulom elasticiteta u zavisnosti od smera primenjene sile, tako da je on najveći u vertikalnom okluzalno-apikalnom smeru gde opterećenje može iznositi i do 50 GPa, a najmanji u horizontalnom vestibulo-oralnom smeru gde iznosi svega 10-12 GPa.

Poseduju osobinu odlične radiosenzitivnosti koja je slična metalu i iznosi od 330% do 510% Al , što nam omogućava u svakom trenutku jasnu uočljivost na rendgen snimcima. (sl. 3)

Istraživanja koja su izvedena od strane samog proizvođača ukazuju na odličnu svetlosnu provodljivost (translucentnost) što nam omogućava korišćenje svetlosno-polimerizujućih materijala za fiksiranje kočića u kanal korena koji omogućavaju značajno bolju retenciju od konvencionalnih cemenata kao što su zink-phosphate ili glass-ionomer-a kojim se fiksiraju metalni kočići.

Bezbojni su ili blago iznijansirani tako da ispunjavaju visokozahtevne estetske norme.

in regard of flexural strenght, module of elasticity, water absorbtion, good radiopacity etc.

In order to achieve optimum results, materials which are used with endodontically treated teeth must have biomechanical and mechanic properties similar to dentin that is to have bonding ability to teeth structure and to be biocompatible in oral environment. Posts of this type have perfect mechanical properties, corosion resistance, and resistance to the forces which damage the material.

Anisotropic nature* of directed fibers of posts results in different module of elasticity depending on the direction of the used force, so that it is the largest in vertical occlusal-apical direction where the load may be up to 50 Gpa, and the smallest in the horisontal vestibulo-oral direction where it is only 10-12 Gpa.

It has the property of perfect radiopacity which is similar to metals ranging from 330%-510%Al, which causes clear detection of posts on radiographs. (Figure 3)

Researches done by the manufacturer point to the perfect translucency which makes possible the usage of light polymerising materials for fixing the posts in the root canal which gives significantly higher retention than conventional cementation of metal posts using zinc-phosphate or glass-ionomer cements.

They are colourless or slightly shaded so that they satisfy high esthetic standards.

**Anizotropnost - nejednake fizičke osobine posmatrane iz različitih uglova*

**Anisotrophic – unequal physical properties observed from different view points*

Slika 3. Odlična vidljivost na Rö snimcima

Figure 3. Exellent radiopacity

Dosadašnja istraživanja

Savremeni sistemi nadogradnje su doprineli razvoju predvidljivih restaurativnih opcija kod endodontski tretiranih zuba. Dosadašnja istraživanja su ukazala da idealni sistemi nadogradnje moraju imati sledeće osobine:

a) fizičke osobine slične dentinu;
b) maksimalnu retenciju postignutu sa malo uklanjanja dentina;
c) distribuciju funkcionalnih pritisaka duž čitave površine korena;
d) estetska kompatibilnost sa definitivnim restauracijama i okolnim tkivom;
e) minimalan pritisak tokom plasiranja i cementiranja;
f) otpornost na dislokaciju;
g) dobra retencija kruničnog dela nadogradnje;
h) mogućnost lake revizije;
i) kompatibilnost materijala sa kruničnim delom;
j) lak za upotrebu, bezbedan i pouzdan;
k) razumna cena troškova.

U pogledu fizičkih osobina noviji materijali su se približili osobinama prirodnih zuba.

Pegoreeti i saradnici su ispitivali ponašanje novih fiber glass kompozitnih kočića simuliranjem analizom beskonačnih elemenata na bidimenzionalnom modelu. Rezultati su upoređivani sa dobijenim rezultatima komercijalnih karbonskih kočića i livene nadogradnje od zlata. Prirodan zub, ili bolje rečeno vraćanje prvobitnog izgleda zuba idealnim materijalima čija je tvrdoća jednaka tvrdoći zubnog tkiva gleđi i dentina, uzete su kao referentni model. Livena nadogradnja od zlata prenosi i koncentriše najveći deo pritiska na prostor između kočića i dentina. Fiber glass kompozitni materijali pokazuju znatno manji pritisak u unutrašnjosti korena, zbog njihove tvrdoće koja je sličnija dentinu zuba, dok se veći deo opterećenja koncentriše u vratnom delu zuba. I pored toga ovi kočići indukuju polje opterećenja slično prirodnom zubu. Opterećenje u vratnom delu se može smanjiti upotrebom materijala manje tvrdoće u izradi kruničnog dela kao što su kompozitne smole, koje integrisane sa kočićem daju stabilan sistem nadogradnje.[28]

Previous research

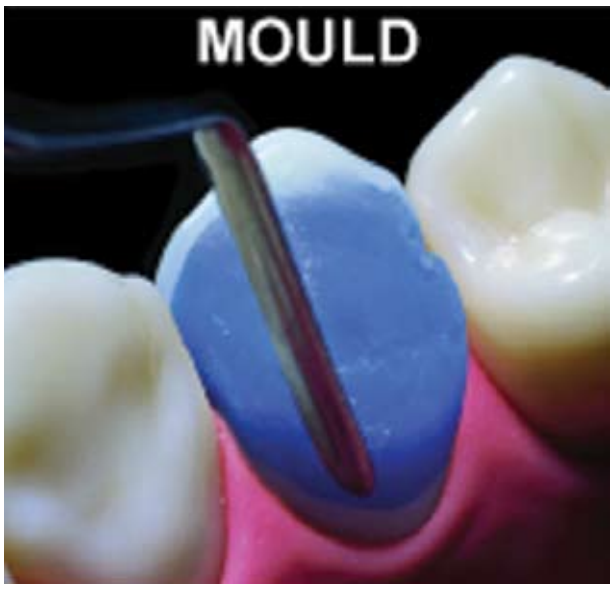
Post and cores contribute in providing predictable restorative options for endodontically treated teeth. After reviewing the literature, it appears that an ideal post system should have the following features:

a) physical properties similar to dentin,
b) maximum retention with little removal of dentin,
c) distribution of functional stresses evenly along the root surface,
d) esthetic compatibility with the definitive restoration and surrounding tissue,
e) minimal stress during placement and cementation,
f) resistance to displacement,
g) good core retention,
h) easy retrievability,
i) material compatibility with core,
j) ease of use, safety and reliability, and
k) reasonable cost.

The biomechanical properties of FRC posts have been reported to be close to that of dentin.

The mechanical behaviour of a new glass fibre composite post was simulated by a FE analysis on a bidimensional model. (Pegoreeti at al.) The results were compared with those obtained considering either a commercial carbon fibre post or a gold alloy cast post. A natural tooth, or better a tooth restored with ideal materials whose stiffness is equal to those of enamel and dentine, was considered as a reference model. The gold cast post-and core produces the greatest stress concentration at the post-dentin interface. On the other hand, fibre-reinforced composite posts do present quite high stresses in the cervical region due to their flexibility and also to the presence of a less stiff core material. The glass fibre composite shows the lowest peak stresses inside the root because its stiffness is much similar to dentin. Except for the force concentration at the cervical margin, the glass fibre composite post induces a stress field quite similar to that of the natural tooth. Stresses at the cervical margins could be lowered using less stiff crown materials, i.e. composite resins, thus obtaining an „integrated“ postcore-crown system.[28]

Slika 4. Multi Core Flow preparat
Figure 4. Multi Core Flow



Slika 5. Multi Core HB
Figure 5. Multi Core HB

U pogledu otpornosti na savijanje u poređenju sa metalnim i keramičkim kočićima pokazuju približne rezultate čelika i titanijuma i bolje vrednosti od cirkonijum keramičkih vrsta. Elastičnost slična dentinu pruža optimalne biomehaničke osobine, što ima za posledicu manje opterećenje korena, a samim tim i manju mogućnost njegovog preloma.

Akkayan i saradnici su ispitivali otpornost na frakturu kod endodotski tretiranih zuba različitim sistemima kočića. Modul elastičnosti kao jedan od najbitnijih faktora je uzet u obzir. Modul elastičnosti titanijuma u poređenju sa dentinom zuba odgovoran je za katastrofalne frakture. Nasuprot njima, quartz fiber kočići imaju manji elastični modul (18 do 47GPa), sličan dentinu, koji može objasniti povoljan model preloma pri dejstvu znatno većih sila. Manocci i saradnici su takođe potvrdili sposobnost ove vrste kočića da smanje rizik od preloma korena na minimum. Glass fiber kočići poseduju znatno bolje uklopljen modul elastičnosti sa prirodnim zubima od cirkonijumskih i titanijumskih kočića. Kod visokog modula elastičnosti cirkonijuma sile opterećenja se prenose direktno na prostor između kočića i dentina bez njihove apsorpcije. Zaključke koje su izveli ukazuju na to da su titanijumski sistemi pokazali najmanju otpornost na sile koje dovode frakture izazivajući katastrofalne posledice po strukturu zuba. Značajno veću otpornost na frakturu zuba pokazali su quarz fiber sistemi. Najbolje rezultate dali su kočići iz grupe fiber glass sistema. Statističke analize frakturnih osobina grupe fiber glass i quarz fiber sistema pokazuju znatno

Akkayan i saradnici su ispitivali otpornost na frakturu kod endodotski tretiranih zuba različitim sistemima kočića. The modulus of elasticity of the different post systems should be taken into account. The high modulus of elasticity of titanium compared to dentin may be responsible for the catastrophic fractures. Conversely, quartz fiber posts have a low elastic modulus (18 to 47 GPa) similar to that of dentin, which may explain the favorable fracture patterns and high fracture loads. Mannocci et al also reported that quartz fiber posts were able to reduce to a minimum the risk of root fractures. Glass fiber posts exhibited a modulus of elasticity much better matched to that of teeth than zirconia and titanium. Due to the high modulus of elasticity of zirconia, forces were transmitted directly to the post/tooth interface without stress absorption. Their conclusions show that titanium systems offer the smallest resistance to the forces which bring to fracture causing disastrous consequences to the tooth structure. The titanium system demonstrated the least resistance to fracture loads and the most catastrophic failures. Significantly higher fracture resistance was observed in teeth restored with the quartz fiber matrix system. The best results were achieved by the posts out of the fiber glass system group. Statistical analysis of the mode of fracture showed that the quartz fiber and glass fiber groups fractured favorably (fractures able to be repaired). Catastrophic fractures were observed in the titanium and zirconia groups.[29]

povoljnije (popravljive) prelome, za razliku od druge dve grupe (titanijum i cirkonijum) kod kojih imamo katastrofalne posledice.[29]

Prenošenje sila opterećenja na kanal korena obrađena analizom konačnih elemenata ukazuju na sličnost sa prirodnim zubima. U poređenju sa livenom nadogradnjom vrše znatno manji pritisak na međuprostor koji za posledicu ima gubitak retencije, i mnogo manji pritisak pri vrhu koji dovodi do frakture apikalnog dela korena.

Korišćenje svetlosno-polimerizujućih materijala za fiksiranje kočića u kanal korena koji omogućavaju značajno bolju retenciju od konvencionalnih cemenata kao što su zink-phosphate ili glass-ionomer-a kojim se fiksiraju metalni kočići, predstavlja još jednu od prednosti korišćenja ovih sistema (sl. 4).

Krunični deo nadogradnje se treba fiksirati za kočić i preostali deo zuba tako da čine jedinstven funkcionalni sistem (zub, nadogradnja, krunica) što je naravno otežano obzirom na činjenicu da se radi o različitim fizičkim osobinama materijala i zubne strukture. Od dostupnih cemenata, zink fosfat cement je jedan od onih koji je već duže vreme testiran. Novije adhezivne lepljive smole su preporučljive za fiksiranje kočića jer omogućavaju spajanje kočića za zubnu strukturu u poređenju sa tradicionalnim cementima koji fiksiranje zasnivaju samo na trenju (sl. 5 i 6). Osim toga, kompozitni nadogradni materijal se može takođe vezati za zubnu strukturu i kočić vezivnim agensima. Vezivanje kočića za zubnu strukturu bi trebalo da poboljša prognozu zuba restauriranog nadogradnjom povećanjem retencije kočića i ojačanjem zubne strukture. Pretpostavlja se da ojačanje zuba dolazi od karakteristika prenosivosti opterećenja vezivnih materijala.

Istraživanja su pokazala da su smolasti lepljivi agensi pokazali dobru adheziju na fiber karbonske i fiber glass kočiće. Adhezija na cirkonijumskim kočićima nije dala zadovoljavajuće rezultate. Takođe je zapaženo da za poboljšanje retencije karbonski kočići ne zahtevaju nikakvu pripremu površine kao što je to slučaj sa cirkonijumskim kočićima. Uprkos stvaranju mikroretencije na cirkonijumskim kočićima, adhezija između kočića i smolasto lepljivog agensa nije bila ujednačena, na taj način se pokazalo da je priroda materijala kočića bila odgovorna za vezivanje kočića za zubnu strukturu.[30]

U poređenju sa metalnim, i drugim nemetalnim sistemima značajan doprinos daju u estets-

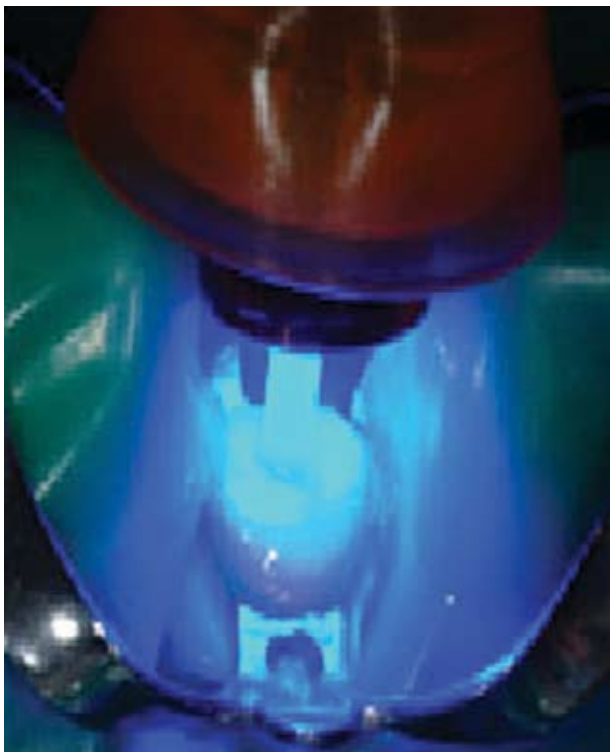
Transmision of load forces to the root canal calculated by analysis of final elements is similar to natural teeth. Comparing with cast alloy, they have considerably less pressure on the interface which results in loss of retention, and much less pressure on apical which brings to the fracture of the apical part of root.

The use of light-polimerising materials for fixing posts in the root canal which bring to much better retention than using the conventional cements such as zinc-phosphate or glass-ionomer for fixing metal posts, is another advantage of using these systems (Figure 4).

Cores may be bonded to the post and tooth structure so that the tooth-post-core-crown system may function as a unit which, as previously mentioned, may be difficult because of the difference in the physical properties of the materials and tooth structure. Of the cements available, zinc phosphate cement is the one that has been time tested. Newer adhesive resin luting agents are advocated for the luting of posts because they are reported to bond the post to the tooth structure in comparison to the traditional cements, which produce only frictional resistance (Figure 5 and 6). Moreover, a composite core material can also be bonded to the tooth structure and post with bonding agents. The bonding of a post to the tooth structure should improve the prognosis of the post-core restored tooth by increasing post retention and by reinforcing the tooth structure. It has been postulated that reinforcement of the tooth is due to the stress distribution characteristics of the bonding materials.

Recently, the importance of bonding on the retention of posts has been demonstrated. It was reported that resin luting agents showed good adhesion to carbon fiber posts and glass fiber posts. The adhesion to zirconia posts was found to be unsatisfactory. It was also observed that to improve retention, the carbon fiber post did not require any surface treatment as compared with the zirconia post. In spite of the creation of microretention on zirconia posts, the adhesion between the post and resin luting agent was not uniform, thus indicating that the nature of post material was responsible for the bonding of the post to the tooth structure.[30]

Comparing with metallic and other nonmetallic systems, they are estheticly much better as they satisfy high-esthetic standards. (Figure 7)



Slika 6. Svetlosna polimerizacija
Figure 6. Light polimerization

Slika 7. Estetska nadogradnja
Figure 7. High esthetic post and core system

kom pogledu jer ispunjavaju i visokozahtevne estetske norme.(sl. 7)

Kočić i krunični deo nadogradnje bi trebalo da budu estetski kompatibilni sa krunicom i okolnim tkivima. Nekoliko autora je naznačilo potrebu da bazna restauracija izgubljenih zubnih tkiva mora imati boju sličnu dentinu.[31,32] Međutim, u situacijama u kojima imamo veća oštećenja zubne strukture i nedostatak razvoja zuba, upotreba konvencionalnih livenih nadogradnji je kompromis estetici. Ovaj estetski koncept je doveo do razvoja estetskih kočića napravljenih od ojačanih smola ili keramike u cilju nadoknade boje kao nedostatka. Metalokeramička kruna sa estetskog aspekta dozvoljava upotrebu različitih kočića i materijala za krunični deo nadogradnje, što nije slučaj kod keramičkih krunica koje su translucentne.[31] Uticaj nemetalnih karbonskih i cirkonijumskih kočića kermičke krunice zavisi od substrukture i debljine krunice.[32]

U slučaju neuspeha endodontskog tretmana ili frakture kočića, osobina ovih sistema da mogu lako da se uklone i zamene bez zančajnijeg gubitka zubne supstance od velikog je značaja. Na žalost, to je otežano kod livenih metalnih nadogradnji i iziskuje uklanjanje zubne strukture oko samog kočića što dovodi do oslabljenja zuba. Karbonski i fiber glass kočići imaju u tom

The post and core material should be esthetically compatible with the crown and the surrounding tissues. Several authors have emphasized the need to have the color of the foundation restoration as close to that of natural dentin.[31,32] However, in clinical situations in which the root has extensive damage or exhibits immature development, the use of a custom cast post would compromise esthetics as the gray tint of the metal may show through the thin root wall. This esthetic concern has led to the development of esthetic posts made from reinforced resins or ceramics in an effort to eliminate the color deficiency. The metalceramic crown will permit the clinician to use any post and core material. All ceramic crowns are translucent and allow metal to show through.[31] The influence of nonmetallic carbon fiber and zirconia post systems on all-ceramic crowns depends on the substructure and thickness of crown.[32]

Ideally, the post system selected should be such that if the endodontic treatment fails or the post fractures, it is easy for the clinician to retrieve the post without substantial loss of tooth structure. Unfortunately, the retrievability of a metal post, especially the cast post and core system is difficult and involves removal of tooth structure around the post, which could further weaken the tooth. Carbon fiber posts have an

smislu prednost nad metalnim i keramičkim kočićima, jer je njihova revizija relativno laka, brza i bezbedna. [31]

Upotreba ovih nemetalnih kočića je relativno laka, brza, bezbedna i pouzdana, što sa relativno niskim troškovima predstavlja još jedan od atributa ovih sistema.

Zaključak

Detaljna znanja osobina zubnih struktura značajna su za bolje razumevanje efekta široke palete različitih dentalnih procedura i principa koji imaju značajan uticaj na integraciju zuba i restauracije. Dakle, izbor odgovarajućih sistema nadogradnje mora zadovoljiti biološke, mehaničke i estetske potrebe svakog zuba ponaosob.

Nemetalni fiber glass kočići su u mnogome doprineli razvoju novih sistema nadogradnji i poboljšali kvalitet protetskog tretmana. Poređenja vršena sa dosadašnjim konvencionalnim materijalima i sistemima pokazuju značajnu prednost u korist novih tehnoloških dostignuća. Veliki pomaci u pogledu nemetalnih kočića, i njihova dugotrajna klinička ispitivanja, sve više zadobijaju preporuke u kliničkoj praksi.

advantage over metallic and ceramic posts in that the removal is relatively easy, rapid, and predictable.[31]

The use of these nonmetallic posts is relatively easy, rapid, safe and reliable, and with reasonable cost are one more atribute of these systems.

Conclusion

Detailed knowledge of tooth structure properties is significant for better noticing of the effects of the wide range of various dental procedures and principals which influence on the tooth integration and restauration. So, the choice of appropriate post and core systems must satisfy biological, mechanical and esthetic needs of each tooth.

Nonmetallic fiber-glass posts contributed greatly into the development of new post and core systems and improved the quality of prosthetic treatment. In comparison with former conventional materials and post and core systems, FRC posts demonstrate significant preference for new technological accomplishments. Thanks to the development of the nonmetallic posts and their long lasting clinical research, they get more recommendations in the clinical practice.

LITERATURA / REFERENCES

1. Mustafa K, Aslihan U, A. Nilgun Ozturk, Sema B, Gurcan E. Bond strength between root dentin and three glass-fiber post systems. J Prosthet Dent 2006; 96:41-6.

2. Edelhoff et al. Core build-up of endodontically treated teeth.Scientific statement of the German Society of Dental Oral and Craniomandibular Sciences 2003

3. Kostka E, Roulet J-F. The root filled tooth in prosthetic reconstruction. Textbook of Endodontology, Blackwell Munksgaard 2003.

4. Aquaviva S. Fernandes, Sharat Shetty, Coutinho I. Factors determining post selection: A literature review. J Prosthet Dent 2003; 90:556-62.

5. Fredriksson M, Astback J, Pamenius M, Arvidson K. A retrospective study of 236 patients with teeth restored by carbon fiber-reinforced epoxy resin posts. J Prosthet Dent 1998; 80:151-7.

6. Rosenstiel SR, Land MF, Fujimoto J. Contemporary fixed prosthodontics. 3rd edition. New Delhi: Harcourt (India) Pvt Ltd; 2001. p. 273-312.

7. Assif D, Gorfil C. Biomechanical consideration in restoring endodontically treated teeth. J Prosthet Dent 1994;71:565–7.

8. Fernandes AS, Shetty S, Coutinho I. Factors determining post selection: a literature review. J Prosthet Dent 2003;90: 556–62.

9. Torbj ¨ orner A, Karlsson S, Syverud M, Henstenpettersen A. Carbon fiber reinforced root canal posts. Mechanical and citotoxic properties. Eur J Oral Sci 1996;102:605–11.

10. King PA, Setchell DJ. An in vitro evaluation of a protype CFRC prefabricated post developed for the restoration of pulpless teeth. J Oral Rehabil 1990;17:599–609.

11. Assif D, Bitenski A, Pilo R, Oren E. Effect of post design on resistance to fracture of endodontically treated teeth with complete crowns. J Prosthet Dent 1993;69:36–40.

12. Isidor F, O¨ dman P, Brondum K. Intermittent loading of teeth restored using prefabricated carbon fiber posts. Int J Prosthodont 1996;9:131–6.

13. Zalkind M, Hochmann N. Esthetic considerations in restoring endodontically treated teeth with posts and cores. J Prosthet Dent 1998;79:702-5.

14. Fernandes AS, Shetty S, Coutinho I. Factors determining post selection: a literature review. J Prosthet Dent 2003;90:556-62.

15. Koutayas SO, Kern M. All-ceramic posts and cores: the state of the art. Quintessence Int 1999;30:383-92.

16. Meyenberg KH, Luthy H, Scharer P. Zirconia posts: a new all-ceramic concept for nonvital abutment teeth. J Esthet Dent 1994;7:73-80.

17. Heydecke G, Butz F, Hussein A, Strub JR. Fracture strength after dynamic loading of endodontically treated teeth restored with different post-and core systems. J Prosthet Dent 2002;87:438-45.

18. Sidoli GE, King PA, Setchell DJ. An in vitro evaluation of a carbon fiber based post and core system. J Prosthet Dent 1997; 78:5-9.

19. Asmussen E, Peutzfeldt A, Heitmann T. Stiffness, elastic limit, and strength of newer types of endodontic posts. J Dent 1999; 27:275-8.

20. Stockton LW, Williams PT. Retention and shear bond strength of two post systems. Oper Dent 1999; 24:210-6.

21. Duret B, Duret F, Reynaud M. Long-life physical property preservation and postendodontic rehabilitation with the composipost. Compend-Contin-Educ-Dent-Suppl 1996; 20:50-6.

22. Mannocci F, Ferrari M, Watson TF. Intermittent loading of teeth restored using quartz fiber, carbon-quartz fiber, and zirconium dioxide ceramic root canal posts. Journal of Adhesive Dentistry 1999;1(2):153–8.

23. Murphy J. Reinforced plastics handbook. Oxford: Elsevier; 1998. p. 63- 106.

24. Lippo VJ Lassila, Johanna Tanner, Anna-Maria Le Bell, Katja Narva, Pekka K Vallittu. Flexural properties of fiber reinforced root canal posts. Dental Materials (2004) 20, 29–36

25. Vallittu PK. Flexural properties of acrylic resin polymers reinforced with unidirectional and woven glass fibers. Journal of Prosthetic Dentistry 1999;81(3):318–26.

26. Sperling LH, Klempner D, Utracki LA. Interpenetrating polymer networks: an overview. 1st ed. Interpenetrating polymer networks. Washington: American Chemical Society; 1994 pp. 3–6.

27. Lastumaki TM, Lassila LVJ, Vallittu PK. The semi-interpenetrating polymer network matrix of fiber-reinforced composite and its effect on the surface adhesive properties. Journal of Materials Science: Materials in Medicine 2003;14: 803–9.

28. Finite element analysis of a glass fibre reinforced composite endodontic post Pegoretti A, Fambri L, Zappini G, Bianchetti M. Biomaterials 23 (2002) 2667–82

29. Resistance to fracture of endodontically treated teeth restored with different post systems. Akkayan B, Gülmez T: J Prosthet Dent 2002; 87:431-7.

30. Factors determining post selection: A literature review Aquaviva S. Fernandes, Sharat Shetty, Ivy Coutinho, J Prosthet Dent 2003;90:556-62.

31. Freedman GA. Esthetic post and core treatment. Dent Clin North Am 2001;45:03-16.

32. Vichi A, Ferrari M, Davidson CL. Influence of ceramic and cement thickness on the masking of various types of opaque posts. J Prosthet Dent 2000;83:412-7.

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