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Cement selection for fixing implant restorations

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SUMMARY

Introduction When intraocclusal space is long enough, and patient has high aesthetic demands, cementing implant restoration is the proper choice. The aim of this study was to assess retentive forces of different cements used for fixing restoration to implant abutment.

Material and method The separation forces were measured between restorations and abutments that were screw retained to the implant replica. The restorations were casted from Co-Cr-Mo alloy. They were cemented to abutments with five different types of cements (composite resin, glass-ionomer, zinc-polycarboxylate, zinc-phosphate and temporary cement). Each cement represented one group and each group included seven samples.

Results Composite resin, glass-ionomer and zinc-polycarboxylate cements showed similar values of retentive forces (256–275 N), while zinc-phosphate cements had slightly lower value (174 N). Temporary cement showed significantly lower value of retentive force (59N). All cements for permanent bonding showed almost the same separation nature. By slow loading, the stress develops, leading to slightly stretched cement and as a consequence, sudden break of cement. Temporary cements also develop stress when slowly loaded, which firstly leads to stretching of cement, and then slight detachment from the implant replica.

Conclusion Temporary cement has the lowest retentive force and is suitable for temporary bonding. Composite resin, glass-ionomer, zinc-polycarboxylate and zinc-phosphate cements have high retentive force, and they can be used for permanent cementation of restoration to abutment. Due to the high values of separation force, and other positive characteristics, composite resin should be cement of choice for bonding restorations to implant abutments.

Keywords: cements; separation force; dental implant restorations

INTRODUCTION

Currently implants are the best option for replacing missing teeth. Restoring an implant includes screw-retained abutment and final restoration on the top. Implant restorations should fulfill all functional, aesthetic and prophylactic requirements of modern prosthodontics. By the mode of transferring pressure, implant restorations belong to three different groups: implant supported, gingiva supported and with mixed support. The most comfortable, and for the patient most acceptable are implant supported restorations. They can be retained on implant abutments in different ways: screw-retained, cemented, or using attachments, magnets and double crowns. Most commonly used options are cementation and screw retaining. Professional opinion is controversial.

Screw retained implant restoration has long tradition. Force of tightening the fixation screw (the torque), is converted to tension strain of a screw (25–35 N/cm), that holds two elements (the abutment and the restoration) together [1–5]. The anchor points of a torque are most often described at the contact of the abutment and the crest module of the fixture (implant body, head of implant). In the case of an ideal passive fitting of the abutment on the crest module of the implant body, the anchor point is the whole contact surface of both of them. When that is achieved, the pressure transmission, to the implant body through the abutment is vertical which is optimal.

In practice, not only that complete and passive fitting of the abutment is difficult to achieve, but the existence of micro gaps are showing that abutment fitting is not passive. Routine radiographic examination can easily reveal it. If abutment does not fit completely and perfectly on the implant body, higher or lower values of torque are being reported [6, 7].

Easy removal of restoration for different reasons is the most advantageous characteristics of this type of fixing the restoration to the abutment. In the cases where there is a small intraocclusal space, i.e. short anatomic crowns, the only appropriate solution is to indicate screw-retained restoration. On the other side, limits in designing the occlusal surface of the restoration and aesthetics are deficiencies for sure. Many clinical studies have reported breaking or loosing the fixation screw as the most often problem that may occur [1, 8, 9].

On the other hand, when the intraocclusal space is bigger, or the patient has high aesthetic demands, cement-retained restoration can be an alternate option, to screw-retained, for fixing restorations on implant abutments [1, 10, 11, 12]. Factors that influence the size of separation force, i.e. retention force, of cement-retained restorations on abutments are: taper of axial surfaces [13], length of the

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abutment, surface roughness and type of cement [14–17]. There are two major groups of cements used in implant prosthetics: temporary cements and cements for permanent bonding. Temporary cements, as its name says, are made for temporary fixation, and their retention force is small. Cements for permanent bonding have higher value of retention force and they are made for definite fixing of the restoration to the abutment.

If we accept that cementing restoration to abutment is an easier technological procedure, than the next question should be what type of cement to choose. Maeyama et al. [18] measured the retentive force (separating the metal core from the abutment, *the Nobel Biocare Easy Abutment*) of different types of cements (temporary zinc-oxide-eugenol cement and cements for permanent bonding: zinc-phosphate, glass-ionomer, fiber-reinforced glass-ionomer and composite resin). Results of the research showed that the retentive force of all cements belongs to three different groups: 1. Temporary cements (56N), 2. Zinc-phosphate cement and glass-ionomer cement (132–158N), 3. Fiber reinforced and composite resin cements (477N).

Similar experiment was done by Mansour et al. [17] who measured retentive force of abutments on ITI implants (*solid abutment*) and metal caps made by casting plastic burn-out caps that were cement retained with six different types of cements. Absolute values in this experiment were a little bit lower because of different methodology of measuring. The lowest value of the retentive force (31.8N) had temporary cement (Temp Bond NE), and the highest (365.3N) composite resin cement (Panavia 21).

Valuable experiment was done by Dudley et al. [14] who measured retentive force between restorations and Straumann synOcta implant abutments using different types of cements: TempBond NE, Ketac Cem and Panavia F that were submitted to artificial aging (thermo cycling by ISO 11405:1995). Absolute values of retentive force were compatible with already known literature data. The value of retentive force of Panavia F cement decreased with growing number of thermo cycles, while the values of Ketac Cem and TempBond NE cements increased. The fact that temporary cement (TempBond NE), after 10.000 cycles (which suits the function of masticatory muscles during a period of one year), showed four times higher retentive force has significant clinical application.

In large *in vitro* study Sheets et al. [19] examined the retentive force of single crowns cemented on abutments. Eleven different cements (eight for temporary and three for permanent bonding) were tested. Each one of them was submitted to ten cycles. The conclusion was that most of them fulfilled minimum of the requests. Authors explained findings as result of limitations of *in vitro* studies (degradation of cement over time in real conditions, high SD, base alloy – Rexillium III that was used for making caps had inferior mechanical characteristics comparing to noble Au alloys and others).

The aim of this study was to assess retentive forces of different cements used for fixing implant restorations to abutments.

MATERIAL AND METHODS

Methodology of the experiment was based on experimental setups used in literature [3, 5, 10, 11, 20, 21] for easier comparison of obtained results.

The implant system used was *Nobel Biocare* system. The force necessary to separate the restoration (metal cap) from the abutment (*Easy abatment*), which was fixed with a screw to the implant replica (*Nobel Biocare, Implant Replica NobRpl RP*), was measured. Original parts of this system and all spare parts recommended by the manufacturer (plastic burn-out caps, *GC Patern Resin* etc.) were used.

Restorations (caps) were casted from a Co,Cr,Mo alloy (Wironit extrahard, Bego, Germany). They were cemented on abutments with different types of cements: Zinc phosphate cement (Hoffmann´s, Germany), Zinc polycarboxylate cement (Harvard, Germany), Glass-ionomer cement (JC Fuji CEM 2, Japan), Temporary cement made specially for implants, for conditionally permanent cementation (Multilink Implant, Ivoclar Vivadent), Composite resin cement (3M, Espe). Each type of cement represented different group and each group had 7 samples. In total there were 35 measurements performed.

The abutment (*Easy abatment)* was screwed to the implant replica (*Nobel Biocare, Implant Replica NobRpl RP*), with a torque of 35 N/cm. The hole in the abutment was closed with the original rubber disc. The plastic burn out cap (*Plastic Coping*) was placed as a base of a future restoration, with retention for testing machine. The sprue, placed from a surveyor in vertical direction, was used as retention. That sprue was modeled to fit the clamp of testing machine (Figure 1).

Restorations (metal caps) were cemented on the abutments with standard procedure. Separation force measurements of the metal cap from the abutment were performed on a universal testing machine Instron 1332, using the dynamometer of 500N, at the laboratory for testing the materials of the Faculty of Technology and Metallurgy University of Belgrade (Figures 2 and 3). During the test, continuous data collecting was done using the A/D card National Instruments NI PCI-6250, and software package LabVIEW (Figure 4).

RESULTS

The forces required to separate (retentive forces) metal copings from abutments fixed with different cements, are given in the Table 1.

DISCUSSION

Cement dissolving due to microleakage is one of the main complications of cement retained conventional restorations that can lead to losing the abutment teeth. Cement retained restorations on implants have similar complications. However, the basic difference is that metal

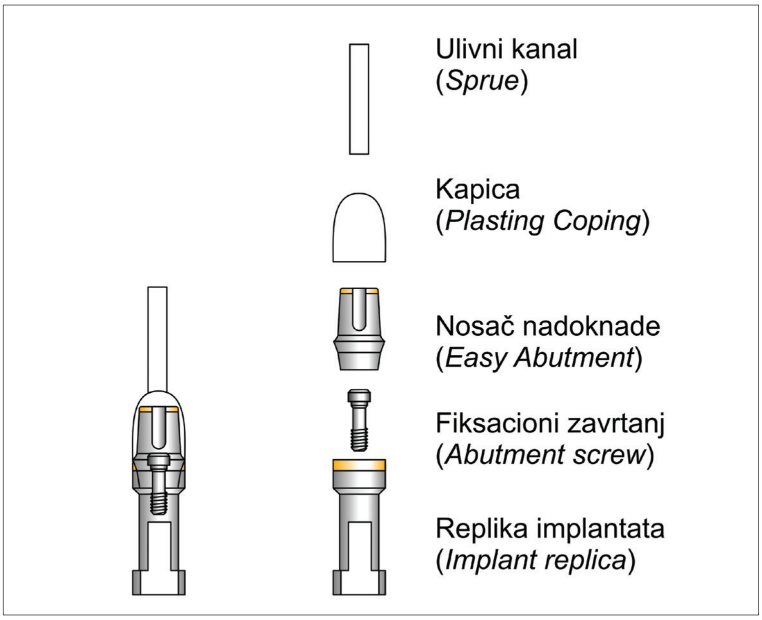

Figure 1. Schematic view of the implant replica, abutment and substructure with retention for testing machine
Slika 1. Šematski prikaz replike implantata, nosača nadoknade i substrukture sa retencijom za hvataljku mosta kidalice

Figure 2. Universal testing machine with the clamps used to measure the separation force
Slika 2. Izgled univerzalne servohidraulične kidalice sa hvataljkama na kojoj je merena sila razdvajanja

Figure 3. Detail of the universal testing machine just before the separation of metal cap from the abutment
Slika 3. Detalj univerzalne servohidraulične kidalice neposredno pre odvajanja metalne kapice od nosača nadoknade

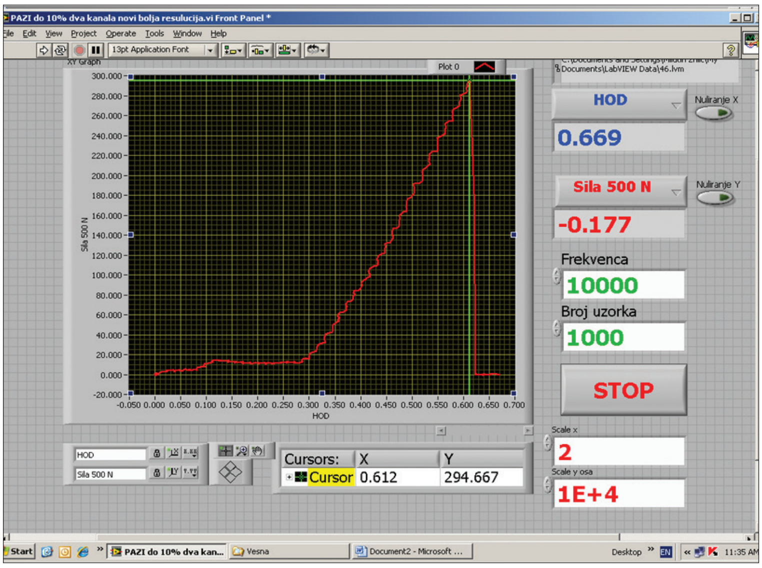

Figure 4. Measured parameters followed on the screen of a computer connected with the universal testing machine Instron 1332
Slika 4. Parametri merenja praćeni na ekranu računara povezanog sa univerzalnom kidalicom *Instron 1332*

Table 1. Retentive force between metal copings and abutments cemented with different cements
Tabela 1. Retenciona sila razdvajanja metalne kapice i nosača nadoknade cementirane različitim cementima

Cement	Brand name/Manufacturer Komercijalno ime/Proizvođač	n	X_{mv} (N)	x_{min} (N)	x_{max} (N)	SD
Zinc phosphate cement Cink-fosfatni cement	Hoffmann's, Germany	7	174	93	334	62.73
Zinc polycarboxylate cement Cink-polikarboksilatni cement	Harvard, Germany	7	256	223	341	41.87
Glass-ionomer cement Glas-jonomerni cement	GC Fuji CEM 2, Japan	7	264	198	302	38.10
Temporary cement Privremeni cement	Multilink implant, Ivoclar Vivadent, Liechtenstein	7	59	33	118	37.48
Composite resin cement Kompozitni cement	3M, Espe, USA	7	275	201	358	44.40

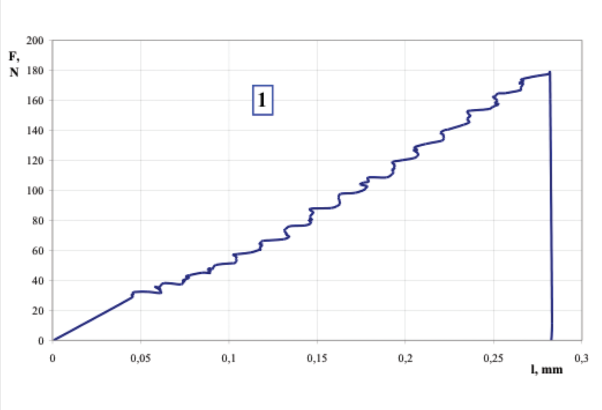

Figure 5. By slow loading, the stress is developed in the cements for permanent fixing, leading to slight stretching (0.1–0.2 mm) and then sudden break of cement.
Slika 5. Pri postepenom opterećenju razvijaju se naponi u cementu za trajno vezivanje koji dovode do neznatnog istezanja cementnog filma (0,1–0,2 mm) i onda do naglog loma cementa.

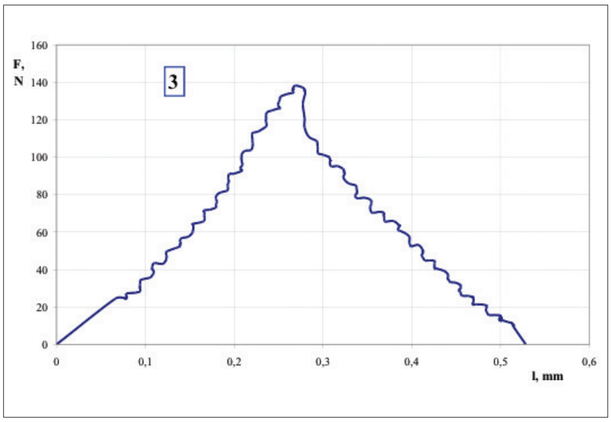

Figure 6. By slow loading, the stress is developed, firstly leading to streching of cement film (0.2–0.3 mm), and then slight detachement of the metal cap from the implant replica.
Slika 6. Pri postepenom opterećenju razvijaju se naponi, koji prvo dovode do istezanja cementnog filma (0,2–0,3 mm), a zatim dolazi do laganog odvajanja kapice od replike.

or ceramic abutment cannot get decay, so the risk of this type of complication is smaller.

Choosing adequate cement was done based on literature data and experience of the Clinic of Prosthodontics at the School of Dental Medicine, Belgrade. Cement for temporary bonding the substructures on implants (Multilink Implant, Ivoclar Vivadent) was specially developed for this purpose. In the literature it can also be found as zinc-oxide-eugenol cement, as an option for temporary cementation of implant restorations. Our pilot study showed extremely low values of retentive forces of this type of cement; therefore it was not included on our experiment.

Sprues were placed in vertical direction on the survey in all specimens without changing the position of the vertical and horisontal handle of the survey. In the pilot study, on one sample, the sprue was placed at acute angle. Breakout force of that specimen was significantly higher comparred to the breakout force where sprues were placed in vertical direction.

There are many studies available in the literature that measured the retentive force of temporary cements and cements for permanent bonding. Interesting studies are those where the petroleum jelly or self-cured resin was added as filler particles to the commercial cements. While petroleum jelly slightly reduced retentive force, self-cured resin in some specific cases (Zn-phosphate cement) increased the retentive force.

Regardless of different opinions about fixing restorations to implant abutments, Misch et al. [11] described the advantages of cement retained implant restorations:

- Passive fitting of the restoration;
- Designing the occlusal surface that allows axial transmission of pressure;
- Easier laboratory manufacturing;
- Shorter working time in the office and
- Better esthetics.

Results of the current study are in accordance with results of Maeyame et al. [9], Mansour A et al. [10] and Pourhmari et al. [17]. The highest retentive force was shown with composite resin cement [22, 23, 24]. As expected, the lowest retentive force was shown with temporary cement. In the current experiment, specially designed cement for temporary fixing of implant restorations on the abutments - Multilink Implant cement was used. Values of separation force of a metal cap from the abutment were X_{mv} 59 N. According to the literature data, all cements for temporary bonding showed the lowest values, which goes from 31 N to 56 N.

Modern testing that was used in the current experiment for measuring forces, beside the values of the separation force, can show the nature of separation. All cements for permanent fixation showed almost the same nature of separation. By slow loading, stress developed, leading to slightly stretching the cement (0.1–0.2 mm) and than, sudden break of cement (Figure 5).

Temporary cement showed different nature of separation. By slow loading, stress developed, which firstly lead to the stretching of the film (0.2–0.3 mm), after which slight detachment of the metal cap from the implant replica happened (Figure 6). This was explained by lower modulus of elasticity of temporary cement likely caused by polymer compound that was one of the ingredients in the temporary cement.

CONCLUSION

Separation forces of metal caps cemented to the implant replica depend on the type of cement. Temporary cements had the lowest retentive force and they were suitable for temporary bonding. Composite resin, zinc-phosphate, zinc-polycarboxylate and glass-ionomer cements have great retentive force that can fix restoration to the abutment for a long period of time. Due to the high values of separation forces, but also other well known characteristics, composite resin and glass-ionomer cements should be given the advantage, depending on the type of restoration, for permanent bonding of the restorations to the implant abutment.

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CONFLICT OF INTERESTS

The authors declare no conflict of interests regarding the publication of this paper.

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Izbor cementa za fiksiranje nadoknada na implantatima

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KRATAK SADRŽAJ

Uvod Kod dovoljno velikog međuviličnog prostora i kod estetski zahtevnih pacijenata fiksiranje zubne nadoknade na implantatima cementom je metoda izbora. Cilj rada je da se na osnovu merenja sile razdvajanja zubne nadoknade od nosača nadoknade, cementirane različitim cementima, utvrde vrednosti retencionih sila za različite vrste cemenata.

Metode Merena je sila razdvajanja nadoknade od nosača nadoknade, koji je fiksiran zavrtnjem za repliku implantata. Zubne nadoknade izlivene su od Co-Cr legure. Nadoknade su cementirane za nosače nadoknada sa pet različitih cemenata. Svaka vrsta cementa predstavljala je posebnu grupu. Merenja svake grupe su obavljana na sedam uzoraka.

Rezultati Kompozitni, glas-jonomerni i karboksilatni cementi su pokazali približno iste vrednosti retencione sile (256–275 N), dok su cink-fosfatni cementi imali nešto manju retencionu silu (174 N). Privremeni cementi su pokazali značajno nižu retencionu silu (59 N). Svi cementi za trajno vezivanje su pokazivali gotovo istovetnu prirodu razdvajanja. Pri postepenom opterećenju razvijaju se naponi u cementu koji dovode do neznatnog istezanja cementnog filma i naglog loma cementa. Pri postepenom opterećenju privremeni cementi razvijaju napone koji prvo dovode do istezanja cementnog filma, a zatim do laganog odvajanja od replike implantata.

Zaključak Privremeni cementi imaju najmanju retencionu silu i pogodni su za privremena cementiranja. Kompozitni, glas-jonomerni, karboksilatni i cink-fosfatni cementi daju veliku retencionu silu koja može trajno fiksirati zubnu nadoknadu za nosač implantata. Zbog velike sile razdvajanja, ali i zbog poznatih dobrih osobina, kompozitnim cementima treba dati prednost u cementiranju zubnih nadonada na implantatima.

Ključne reči: cementi; sila razdvajanja; zubne nadoknade na implantatima

UVOD

Suština ugradnje implantata je stvaranje mogućnosti za izradu zubne nadoknade. Na ugrađeni implantat se postavlja nosač nadoknade koji nosi zubnu nadoknadu. Zubna nadoknada na implantatima treba da ispunjava sve funkcionalne, estetske ali i profilaktičke zahteve savremene stomatološke protetike. Zubne nadoknade na implantatima se po načinu prenosa pritiska dele na: implantatno nošene nadoknade, mešovito nošene naoknade i gingivalno nošene nadoknade. Najkomfornije su, i za pacijenta najprihvatljivije, svakako, implantatno nošene nadoknade. Ove nadoknade se mogu fiksirati za nosače nadoknade na više načina: fiksacionim zavrtnjima, cementiranjem, atečmenima, magnetima i dvostrukim krunama. Najčešće primenjivani načini fiksacije su cementiranje i fiksacija zavrtnjima. Fiksiranje zubne nadoknade za nosač nadoknade cementom ili fiksacionim zavrtnjem je podelilo stručnu javnost.

Vezivanje zubne nadoknade za implantate fiksacionim zavrtnjima ima dugu tradiciju. Sila zatezanja zavrtnja (obrtni momenat) konvertuje se u napon naprezanja zavrtnja (25–35 Ncm), koji drži dva elementa (nosač nadoknade i nadoknadu) zajedno [1–5]. Tačke oslonca momenata sila se najčešće opisuju na kontaktu nosača nadoknade i glave implantata. U slučajevima idealnog naleganja nosača nadoknade na glavu implantata tačka oslonca je cela dodirna površina glave implantata i nosača nadoknade. U tim slučajevima je i prenos pritiska sa nadoknade preko nosača nadoknade na implnatat vertikalan, tj. najpovoljniji.

U praksi se ne sreće često potpuno i pasivno naleganje nosača nadoknade na glavu implantata, već se sreću mikropukotine koje ukazuju da naleganje nosača nadoknade nije pasivno. Rutinsko Rdg snimanje upozorava na ovu pojavu. Kao posledica greške da nosač nadoknade ne naleže potpuno i pasivno na glavu implantata je pojava većih ili manjih momenata sila [6, 7].

Mogućnost povremenog skidanja zubne nadoknade u cilju prevencije i terapije mekih tkiva, ali i manjih intervencija na nadoknadi, svakako su prednosti ovog tipa vezivanja nadoknade za nosače nadoknada. Prednost fiksacionim zavrtnjima treba dati u slučajevima malog interokluzionog prostora, odnosno kratkih kliničkih kruna. Sa druge strane, limiti u dizajnu okluzalnog kompleksa i estetika su svakako nedostaci. Mnoge kliničke studije ukazuju da je gubitak fiksacionog zavrtnja najčešći problem [1, 8, 9].

Kod dovoljno velikog međuviličnog prostora i kod estetski zahtevnih pacijenata fiksiranje zubne nadoknade cementom je metoda izbora [1, 10, 11, 12]. Faktori koji utiču na veličinu sile razdvajanja, odnodno retencione sile, cementiranjem zubnih nadoknada na implantatima su: koničnost aksijalnih površina [13], dužina nosača nadoknade, obrada površine, tip cementa [14–17]. Postoje dve velike grupe cemenata u implantnoj protetici: privremeni cementi i cementi za trajno vezivanje. Privremeni cementi se primenjuju za privremeno vezivanje i njihova snaga vezivanja je mala. Cementi za trajno vezivanje imaju veliku snagu vezivanja i njihova indikacija je trajno vezivanje zubnih nadoknada.

Ako prihvatimo činjenicu da je fiksiranje zubnih nadoknada za nosače nadoknada cementom tehnički jednostavnija procedura, onda je sledeće pitanje koje nam se nameće izbor cementa. Literatura je bogata radovima na ovu temu. U redovima koji slede iznećemo najčešće citirane reference.

Maeyama i sar. [18] merili su retencionu silu (odvajanje metalne kapice od nosača nadoknade) različitih vrsta cemenata (privremeni ZnOE cement i cementi za definitivno cementiranje: cink-fosfatni, glas-jonomerni, vlaknima ojačan glas-jonomerni i kompozitni cement). Rezultati istraživanja pokazuju da se retenciona sila svih cemenata može svrstati u tri grupe: privremeni cementi (56 N), cink-fosfatni i glas-jonomerni cementi (132–158 N) i smolom ojačani i kompozitni cementi (477 N).

Sličan ekperiment izveli su i *Mansour* i sar. [17] mereći retencionu silu nosača nadoknade ITI implantata i metalnih kapica dobijenih livenjem plastičnih kapica cementiranih sa šest različitih cemenata. Apsolutne vrednosti su u ovom eksperimentu bile nešto manje zbog različite metodologije merenja. Najmanju vrednost retencione sile (31,8 N) imao je privremeni cement (*Temp Bond NE*), a najveću retencionu silu (365,3 N) kompozitni cement (*Panavia 21*).

Vredan eksperiment obavili su i *Dudley* i sar. [14] ispitujući retencionu silu različitih cemenata. *Straumann synOcta* nosači nadoknade cementirani *TempBond NE, Ketac Cem i Panavia F* cementom podvrgnuti su veštačkom starenju (termocikliranju prema ISO 11405:1995). Apsolutne vrednosti retencione sile su bile saglasne sa već opisanim literaturnim podacima. Eksperiment koji je simulirao uslove u ustima pokazao je da vrednost retencione sile kod cementa *Panavia F* opada sa brojem termociklusa, dok vrednosti cemenata *Ketac Cem* i *TempBond NE* rastu. Značajnu kliničku primenu ima činjenica da cement za privremeno cementiranje (*TempBond NE*), posle 10.000 ciklusa (odgovara jednogodišnjoj funkciji mastikatornih mišića), ima oko četiri puta veću retencionu silu razdvajanja na kraju eksperimenta u poređenju sa vrednostima dobijenim na početku eksperimenta.

U veoma obimnoj *in vitro* studiji *Sheets* i sar. [19] ispitivali su retencionu silu pojedinačnih krunica cementiranih za nosače nadoknada. Studija je obuhvatila testiranje 11 različitih cemenata (osam cemenata za privremeno i tri cementa za definitivno cementiranje). Broj ponavljanja za svaki cement bio je 10. U zaključku, autori naglašavaju da je teško preporučiti najbolji cement, jer većina ispunjava minimum zadatih zahteva. Ovako oprezan stav autori objašnjavaju limitom *in vitro* studija (degradacija cementa u funkciji vremena u realnim uslovima, velika SD, bazna legura – *Rexillium III* koja je korišćena za izradu kapica lošijih je mehaničkih karakteristika u poređenju sa plemenitim Au legurama i dr.).

Cilj ovog rada je da se na osnovu pregleda literature i merenja sile razdvajanja zubne nadoknade od nosača nadoknade, cementirane različitim cementima, utvrde vrednosti retencionih sila za različite vrste cemenata i dâ preporuka za izbor cementa.

MATERIJAL I METOD

Materijal i metod eksperimenta su dizajnirani po ugledu na najčešće citirane eksperimente [3, 5, 10, 11, 20, 21] radi mogućeg poređenja i diskusije dobijenih rezultata sa literaturnim podacima.

Za istraživanje je odabran sistem *Nobel Biocare*. Merena je sila razdvajanja nadoknade (metalne kapice) od nosača nadoknade (*Easy abatment*), koji je fiksiran zavrtnjem za repliku implantata (*Nobel Biocare, Implant Replica NobRpl RP*). Korišćeni su originalni delovi sistema i fabrički preporučeni pomoćni materijali (plastične kape za livenje, *GC Patern Resin* i dr.).

Zubne nadoknade (kapice) izlivene su od legure Co-Cr-Mo (*Wironit extrahard, Bego, Germany*). Nadoknada je cementirana za nosač nadoknade različitim cementima: cink-fosfatnim cementom (*Hoffmann´s, Germany*), karboksilatnim cementom (*Harvard, Germany*), glas-jonomernim cementom (*JC FujiCEM 2, Japan*), namenskim privremenim cementom za uslovno trajno cementirane implantata (*Multilink Implant, Ivoclar Vivadent*) i kompozitnim cementom (*3M, Espe*).

Svaka vrsta cementa predstavljala je posebnu grupu. Merenja svake grupe su obavljena na sedam uzoraka. Ukupno je obavljeno 35 merenja.

Za repliku implantata (*Nobel Biocare, Implant Replica NobRpl RP*) zavrtnjem (*Abutment screw*) pričvršćen je nosač nadoknade (*Easy abatment*), pod naponom naprezanja zavrtnja od 35 Ncm. Otvor nosača nadoknade zatvoren je originalnim gumenim diskom. Na nosač nadoknade je postavljena plastična kapica, kao osnova buduće krunice, sa retencijom za kidalicu. Kao retencija je korišćen ulivni kanal postavljen u paralelometru iz vertikalnog pravca. Ulivni kanal je modelovan tako da odgovara hvataljci mosta kidalice (Slika 1).

Zubne nadoknade (metalne kapice) cementirane su za nosače nadoknade standardnom procedurom. Merenja sile razdvajanja metalne kapice od nosača nadoknade obavljena su na univerzalnoj servohidrauličkoj kidalici *Instron 1332*, uz upotrebu silomera od 500 N, u Laboratoriji za ispitivanja materijala Tehnološko-metalurškog fakulteta, slike 2 i 3. Tokom ispitivanja obavljano je stalno prikupljanje podataka A/D karticom *National Instruments NI PCI-6250* korišćenjem softverskog paketa *LabVIEW* (Slika 4).

REZULTATI

Rezultati merenja sile razdvajanja (retencione sile) zubne nadoknade (metalne kapice) od nosača nadoknade cementirane različitim cementima date su u Tabeli 1.

DISKUSIJA

Rastvaranje cementa usled lošeg rubnog zatvaranja je osnovna komplikacija cementiranja konvencionalnih zubnih nadoknada koja može dovesti do gubitka zuba nosača nadoknade. Zubne nadoknade cementirane na implantatima imaju slične komplikacije. Ipak, osnovna razlika je u tome što se metalni ili keramički nosač nadoknade ne rastvara i opasnost od ovakve vrste komplikacija je ovde manja.

Pri izboru cementa rukovodili smo se literaturnim podacima i iskustvom Klinike za stomatološku protetiku Stomatološkog fakulteta. Cement za privremeno fiksiranje suprastruktura na implantatima – Multilink posebno je dizajniran upravo za ovu namenu. U literaturi je opisan i ZnOE cement, kao sredstvo za privremeno fiksiranje zubnih nadoknada na implantatima. Naša pilot-studija je pokazala izuzetno niske vrednosti retencione sile kod suprastruktura vezanih ovim cementom, pa stoga ovaj cement nije uključen u eksperiment.

Ulivni kanali su postavljani iz vertikalnog pravca u paralelometru. Ulivni kanali svih uzoraka su postavljani iz istog pravca ne pomerajući položaj vertikalne i horizontalne ručice paralelometra. Ovaj način postavljanja ulivnih kanala u saglasnosti je sa literaturnim podacima. U pilot-studiji na jednom uzorku postavili smo ulivni kanal pod oštrim uglom u odnosu na vertikalu. Sila kidanja tog uzorka bila je značajno veća od sile kidanja uzoraka gde su ulivni kanali postavljeni iz vertikalnog pravca.

Obavljena su mnoga merenja retencione sile cementima za privremeno i definitivno cementiranje. Interesantni su eksperimenti koji su komercijalnim cementima dodavali vazelin ili autopolimerizujuće smole kao punioce. Dok vazelin blago redukuje retencionu silu privremenih cemenata, autopolimerizujuće smole samo u nekim slučajevima (cink-fosfatni cement) pojačavaju retencionu silu.

Iako su mišljenja o načinu vezivanja zubne nadoknade za nosače nadoknade na implantatima podeljenja, autorima ovog rada najbliže je mišljenje koje ima *Misch* [11] da izbor veze treba da bude cement, jer za to postoji nekoliko razloga:

– pasivno naleganje zubne nadoknade;
– modelovanje okluzalne površine koja će omogućiti aksijalni prenos pritiska;
– jednostavnija laboratorijska izrada;
– kraće vreme kliničkog rada i
– bolja estetika.

Dobijene vrednosti sila razdvajanja metalne kapice od replike implantata cementirane različitim cementima u saglasnosti su sa rezultatima koje su prikazali *Maeyama* i sar. [9], *Mansour* i sar. [10] i *Pourahmari* i sar. [17]. Najveću retencionu silu, prema literaturnim podacima, imaju kompozitni cementi [22, 23, 24].

Prema očekivanjima, najmanju retencionu silu pokazali su privremeni cementi. U našim istraživanjima kao privremeni cement korišćen je specijalno dizajniran cement za fiksiranje zubnih nadoknada na implantatima – implantni cement Multilink. Mi smo dobili vrednost sile razdvajanja metalne kapice od abatmenta od X_{mv} 59 N. U literaturi su svi cementi za privremeno cementiranje pokazivali najmanje vrednosti, koje su se kretale od 31 N do 56 N.

Savremena kidalica koju smo koristili za merenje sila, pored vrednosti razdvajanja sklopa, pokazivala je i prirodu razdvajanja. Svi cementi za trajno vezivanje pokazivali su gotovo istovetnu prirodu razdvajanja. Pri postepenom opterećenju razvijaju se naponi u cementu koji dovode do neznatnog istezanja cementnog filma (0,1–0,2 mm) i naglog loma cementa (Slika 5).

Cement za privremeno cementiranje pokazao je drugačiju prirodu razdvajanja metalne kapice od nosača nadoknade fiksirane za repliku implantata. Pri postepenom opterećenju razvijaju se naponi u cementnom filmu koji prvo dovode do istezanja cementnog filma (0,2–0,3 mm) pri maksimalnom opterećenju, a zatim ne dolazi do naglog pucanja cementnog filma već do laganog odvajanja kapice od replike (Slika 6). Ovakvo ponašanje cementnog filma za privremeno cementiranje tumači se manjim modulom elastičnosti, koje potiče, verovatno, od polimernih jedinjenja koja su deo recepture cemenata za privremeno cementiranje.

ZAKLJUČAK

Merenje sile razdvajanja metalne kapice od nosača nadoknade fiksirane za repliku implantata pokazalo je da retenciona sila zavisi od vrste cementa. Privremeni cementi imaju najmanju retencionu silu i pogodni su za privremena cementiranja. Kompozitni, cink-fosfatni, karboksilatni i glas-jonomerni cementi daju veliku retencionu silu koja može fiksirati zubnu nadoknadu za nosač implantata u dužem periodu. Zbog velike sile razdvajanja, ali i zbog poznatih dobrih osobina, kompozitnim cementima treba dati prednost u definitivnom cementiranju zubnih nadoknada na implantatima.