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ANALYSIS OF EFFECTS OF MECHANICAL LOADS, THERMAL FLUCTUATIONS AND CHEMICAL FACTORS ON THE BOND STRENGTH OF RESIN CEMENT TO TITANIUM AND CoCrMo ALLOYS IN IMPLANT SYSTEMS – *IN VITRO* STUDY

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Abstract: Introduction: Cements in the oral cavity are subjected to many factors affecting cement retention, the major ones being masticatory loads and thermal stress. The gold standard in cementing restorations in the contemporary implant prosthodontics are resin cements while their predisposition to the effects of oral cavity environment presents a major factor for the efficiency of dental implant treatment.

Material and method: In the study, we used 40 test models made up of a combination of original components of the Nobel Biocare system (implant replica NobRplN and titanium suprastructure Easy abatement NP 0.75) and the restoration cast in CoCrMo alloy. The specimens were divided in 4 test groups with 10 specimens each. The specimens in each group were cemented with resin composite cement with or without using the metal primer. Group I – Multilink Implant, IvoclarVivadent, Liechtenstein, Group II – Multilink Implant, IvoclarVivadent, Liechtenstein + Monobond Plus, Group III G-CEM LinkAce®, Group IV - G-CEM LinkAce® + GC Metalprimer II. The specimens were stored in 100% relative humidity for 24 hours whereupon each group underwent 5 rounds of testing. The specimens were subjected to thermal and mechanical load cycling tests whose number reflected the period of simulation of the function in the oral cavity (unloaded specimens, 7 days of function, 3 months, 6 months and 12 months). The retention force was measured by the Universal testing machine.

Results: The highest retention values of the resin composite cement were recorded during the initial tests, which then declined in the subsequent rounds of testing. The biggest fall was measured in the first week after the cementation, while the cross-comparison of the later rounds of testing did not show any statistically significant differences. The values of the retention force of resin composite cements 12 months after the cementation dropped by one third of the initial values. All recorded values were higher in the specimens with primer coating.

Conclusion: Masticatory forces and temperature changes in the oral cavity reduced the retention values of resin cement, but its values after 12 months of function were still high and provided stability and retention of the restoration in function. The usage of metal primer had a significant effect on retention force values at all levels of testing.

Keywords: implantoprosthetics, composite cements, retention, mechanical cycling loading, temperature fluctuations, metal primers.

1. INTRODUCTION

Owing to the high biocompatibility and optimal mechanical properties, the usage of titanium as a constituent material for dental implants and the metal-ceramic restoration, as well as the mobile restoration, has increased in recent years [1]. Today the implant-supported crowns are well accepted and a highly successful solution for the substitute of individual missing teeth, or the complete reconstruc-

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tion of toothless jaws. The success of implantoprosthetic therapy depends on more factors: a good osseo-integration of implants, a qualitative prosthetic reconstruction and the connection between the implant and the restoration itself [2]. Restorations can be fixed for the implant abutments in different ways. [3,4] One of the ways, which has been applied most frequently, is the cement fixation. Dental cements provide the retention inter-surface, filling the space between the natural tooth and the crown or the abutment and the crown, and enable the compensation of little discord in leaning. A few kinds of permanent cements, which provide different levels of the restoration retention, are used in practice. Composite cements, due to their exquisite mechanical and esthetic characteristics, and qualitative marginal seals, present the gold standard in cementing contemporary implantoprosthetic restorations. The mechanism of bonding composite cements is based on the adhesive bonding with the surface. Originally, these cements were developed for cementing restorations on natural teeth, no matter whether we speak about their bond with enamel or with dentin. The protocol of cementing with composite cements means the preparation of the tooth's surface by eroding it slightly with inorganic acids and applying the adhesive system, which ties the cement with the surface [5,6]. This conventional protocol of dentine preparation on the natural tooth does not have sense when we speak about the restoration fixation on the implant abutments, which are mainly made of titanium or zirconium dioxide. Studies have shown significantly lower retention values in comparison to the retention, which the same cement shows in combination with the surface of a natural tooth, out of which the fact arises that it is necessary to use additional mechanisms in order to strengthen the bond quality of the composite cement and alloys, which restorations and implant abutment are made of in implantoprosthetics [7–10]. As observed in the sense of clinical application, weaker mechanical bond of the restoration and the implant abatment can result in opening the marginal hole, loosening the cement and de-cementing of the restoration. Thanks to their good performances, composite cements present cement of choice in modern implantoprosthetics. These cements possess exceptionally good mechanical properties, they achieve high retention, due to the resin content they have qualitative edge sealing, they are resistant to pH changes, they are minimally prone to melting in the oral cavity and they fulfill high esthetic standards [11]. Evaluation of the usage of composite cements in implantoprosthetics has been the topic of numerous researches [12–15].

Disregarding the high performance of composite cements, the need for them in cementing the restorations on implant abutment significantly limits the quality of the bond with the metal. All attempts to improve the bond of the composite and the metal go in two directions – modification of the metal surface itself and the usage of the supporters of the bond between the metal and the composite – primer. The problems of the bond between the composite cement and titanium or alloys, that restorations are made of, is one of the current issues in modern implantoprosthetics and a lot of researchers have dealt with the above mentioned theme [16–18]. Like the majority of other cement systems, the composite cements were originally developed for cementing the fixed restorations in conventional prosthetics, where the inner surface of a crown and the surface of a natural tooth present the bonding surfaces. The question arises how these cements are tied to the smooth surface of the titanium or ceramics abutment. Is it necessary to change the treatment with dental silanes in order to achieve the qualitative bond of the cement with the abutment and the crown and how do these cements behave in the function and under the influence of the oral cavity factors during a longer period of time? The aim of this paper is to determine the value of the retention bond, which is accomplished by the composite cement with the restoration and implant abutment, with or without the primer application onto the metal, immediately after the definite cementing, as well as to evaluate the quality of the cement and restoration bond during the period of one year, under the influence of different factors, which exist in the oral cavity: high percentage of humidity, changes of temperature and masticatory load.

2. MATERIAL AND METHODS

In the scope of this research, we used 40 experimental models, which were made of implant replica (Nobel Biocare, Implant Replica Nob Rpl NP), Easy abutment NP 0.75 of titanium, and restorations were casted in CoCrMo alloy (Bond NF – Nikl free, Interdent, Slovenia). The abutment, on which the restoration is made, is fixed into the implant with a special fabric key (picture 1). The access channel of abutment is, aiming at preventing the cement break-through, closed with a temporary light-polymerizing composite (Temp – it, Spident, Korea). Restorations are, aiming at standardizing the sample, made according to the silicone mold of the occlusal two-thirds of the crown of the acrylic Frasaco tooth – the second lower premolar, whereas the inner aspect of the restoration and the thickness of the cement space were standardized by using of plastic caps for casting (Plastic Coping Easy Abutment Engaging NP 2pkg). After the finished casting, the outer surface of the restoration was highly polished, whereas the inner surface of the restoration was abraded with 50 micron-sized particles of aluminium oxide, in order to improve the micromechanical retention (picture 2).

Picture 1. Experimental sample (part I- implant replica and abutment)

Picture 2. Experimental sample (part II- crown)

All samples were adequately prepared for cementing with a traditional method, by cleaning with gas and alcohol and drying with a stream of air, in order to secure clean and dry bonding surfaces. Composite cements Multilink Implant, IvoclarVivadent, Liethenstein and G-CEM LinkAce®, with or without additional application of primer for the metal, were used for cementing. Four experimental groups, each of them containing ten samples, were formed (table 1).

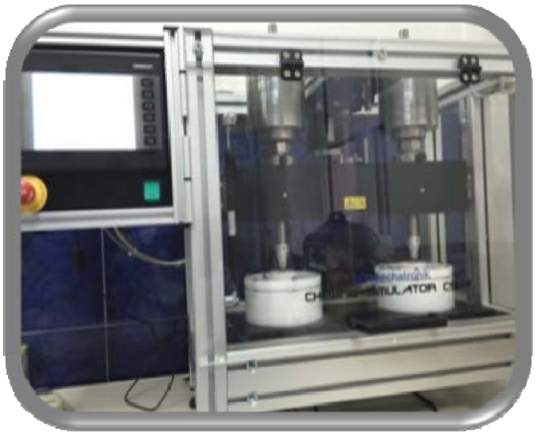
Table 1. Experimental groups

Group	Number of samples	Cement	Metal primer
1	10	Multilink Implant, IvoclarVivadent, Liethenstein	Without usage of metal primer
2	10	Multilink Implant, IvoclarVivadent, Liethenstein	Monobond Plus
3	10	G-CEM LinkAce®	Without usage of metal primer
4	10	G-CEM LinkAce®	GC Metalprimer II

Restorations were fixed on samples, which were prepared in that way, with composite cements for definite cementing, according to the previously determined experimental plan. In groups 2 and 4, metal surfaces were treated with appropriate primers for metal before the cement application. Further procedure was the same for all experimental groups. The restoration with cement, after placing it onto the abutment, is in the hydraulic press, under the controlled continuous pressure of 5 kg, and the initial light polymerization of the cement is performed in the area of the marginal edge lasting for three seconds. Rubbery consistency, which the extruded cement receives by initial polymerization, facilitates the removal of the cement excess in one piece, without damaging the marginal edge area. Having in mind the fact that the crown is made of metal, polymerization light does not pass through it, therefore, the restoration is left to be still and under the controlled pressure in the next seven minutes, which is necessary to finish the chemical polymerization of the cement. Having finished the cementing process, the samples of all four experimental groups were stored for the next 24 hours in the conditions of 100% humidity and 37°C temperature in order to make the conditions approximate to those in the oral cavity. After that, with the aim of simulating the masticatory load and temperature fluctuations, to which the restoration is exposed in the oral cavity, the samples were subjected to the number of 500 cycles of thermocycling and to the rounds of mechanical cyclic load, whose number corresponded to the period of function simulation in the oral cavity in each round of testing (Picture 3). Six rounds of testing were performed within each experimental group and according to the previously determined schedule (Table 2). Retention force was measured in The Universal testing machine (Picture 4).

Table 2. The testing schedule

Cycles of testing	**Simulated period of function**	**Number of masticatory cycles (mechanical cycles loading)**
1	0	0
1	7 days	192
2	3 months	2 500
3	6 months	5 000
4	9 months	7 500
5	12 months	10 000



Picture 3. The machine for simulating the occlusal load

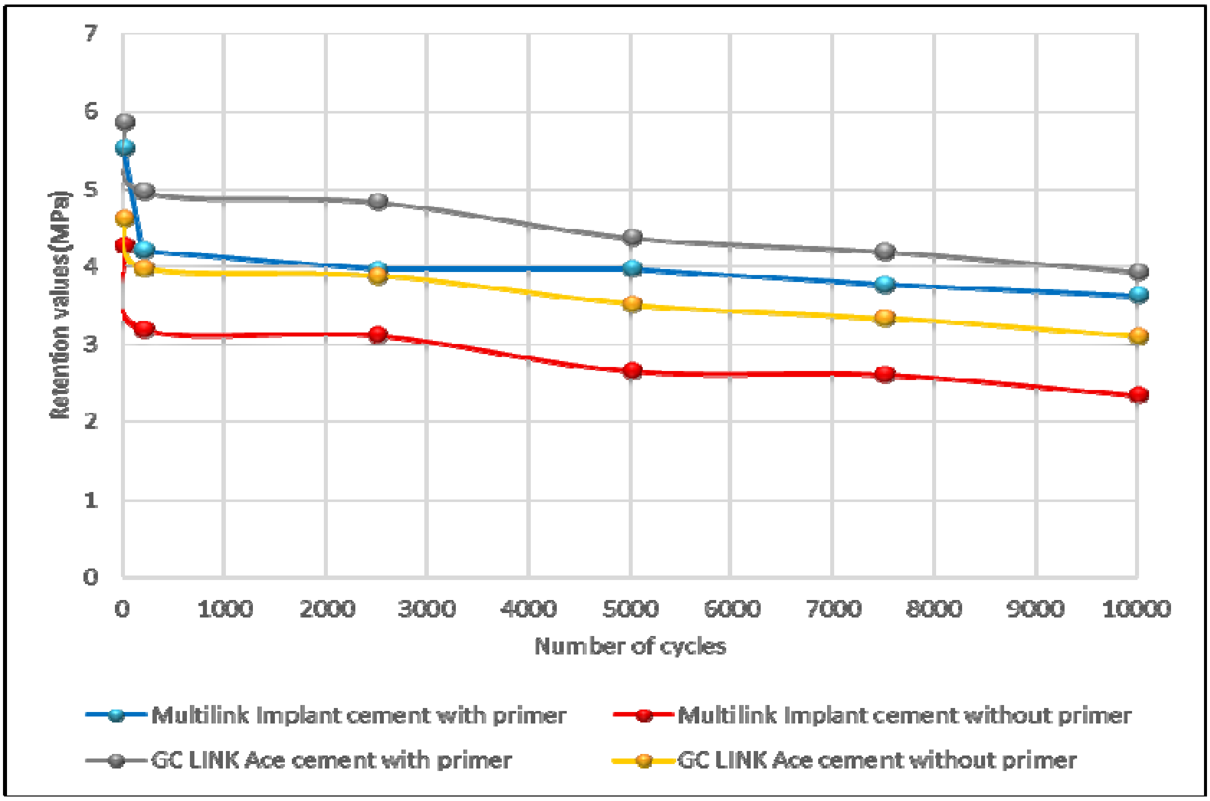
Picture 4.Universal testing machine with the fixed sample and the graph in which the retention force was noted

In total, 40 measurements were performed, 10 in each experimental group.

3. RESULTS

The results of this study, in which the samples were exposed to the simulated conditions of the oral cavity during the examination, show that the samples, in which primer for the metal was used, show a higher retention value than samples in which primer was not used on all levels of measuring for both examined cements. In comparison to the retention values, which were measured in the initial phase (24 hours after cementing), after the exposure to mechanical cyclic load of 10000 cycles (one year of function in the oral cavity), the retention of both examined cements decreases on average for 1/3 in comparison to the initial phase of testing. The change in values of the retention force of the examined cements, in the sample groups with or without the used primer, during the first year of function, was shown in Graph 1. Values are expressed in MPa.

Table 3 presents average retention values with standard deviations for the examined cements through all rounds of testing (initially, after 7 days of function – 192 cycles of compressive cyclic loading, after three months of function – 2500 cycles of compressive cyclic loading, after 6 months – 5000 cycles of compressive cyclic loading, after 9 months – 7500 cycles of compressive cyclic loading and after 12 months – 10000 cycles of compressive cyclic loading).



Graph 1. Comparison of the retention values of all examined groups during the first year of function.

Table 3. Average retention values with standard deviations for the examined cements

Cement		0 cycles of compressive cyclic loading	192 cycles of compres-sive cyclic loading	2500 cycles of compres-sive cyclic loading	5000 cycles of compres-sive cyclic loading	7500 cycles of compres-sive cyclic loading	10000 cycles of compressive cyclic loading
Multilink Implant cement with used primer	AC	5,53	4,21	3,98	3,98	3,78	3,63
	SD	1,16	0,73	1,18	0,87	0,88	1,00
Multilink Implant cement without used primer	AC	4,28	3,19	3,12	2,66	2,61	2,34
	SD	0,78	0,50	0,53	0,37	0,31	0,26
GC LINK Ace with used primer	AC	5,86	4,97	4,84	4,38	4,19	3,94
	SD	1,09	1,02	1,00	1,05	0,76	0,73
GC LINK Ace without used primer	AC	4,64	3,99	3,89	3,52	3,35	3,11
	SD	1,09	0,70	1,26	0,96	0,89	0,81

Mann-Whitney U test showed statistically significant difference between the values of the retention force of samples which were cemented with the Multilink Implant composite cement with the used primer and the samples without the used primer ($p<0.05$). The samples, which were cemented with the GC LINK Ace composite cement, in which the primer was used in comparison to samples which were cemented without the usage of primer, showed statistically significant difference ($p<0.05$) in all rounds of testing, except the third and fourth round of testing (after simulated 3 and 6 months of function), where statistically significant difference was not registered ($p>0.05$). Values of the retention force of the samples cemented with the Multilink Implant composite cement without the used primer are statistically significantly lower ($p<0.05$) in comparison to samples cemented with the GC LINK Ace composite cement without the used primer, which were measured on the last three levels of testing, whereas there is no statistically significant difference ($p>0.005$) between the values of the retention force of both examined cements with the used primer after one year of function in the oral cavity. During the initial measurement, the GCE LINK Ace cement with the used primer showed the highest retention force (5.86 ± 1.09 MPa), and it is followed by the Multilink Implant cement with the used primer (5.53 ± 1.16 MPa), GC Link Ace without the used primer (4.64 ± 1.09 MPa) and the Multilink Implant cement without the used primer (4.28 ± 0.78 MPa). After one year of function, retention values for the GC LINK Ace cement with the used primer amount to (3.94 ± 0.73 MPa), followed by the Multilink Implant cement with the used primer (3.63 ± 1.00 MPa), GC LINK Ace without the used primer (3.11 ± 0.81 MPa), and the Multilink Implant cement without the used primer (2.34 ± 0.26 MPa). The greatest decrease of the retention value has been recorded in the first seven days after cementing, whereas the later decrease of values unfolds in a more moderate way, which is shown by the fact that there is no statistically significant difference between the values of the retention forces by mutual comparison of the next measurements.

4. DISCUSSION

Composite cements present the gold standard in contemporary implantoprosthetics. Their mechanism of bonding was originally adapted to the surface of the ground natural tooth and cannot be, as such, developed completely on metal surfaces of the abutment and restoration in implantoprosthetics. It is evident that additional mechanisms are necessary for achieving the quality bond of the composite cement with the surface of the metal. Improvement of the bond of the composite with the metal surfaces has been the subject topic of numerous researches [19−22] and current efforts are made in the following directions: the activation of the chemical bond by using different bond supporters – primers, treating the metal surface with Al_2O_3 particles abrasion aiming at improving the mechanical retention and the combination of these two mechanisms. [23,24]. Chemical bond improvement is achieved by the application of primers for the metal. Modern systems combine adhesive resins with chemically active monomers, which can be connected directly onto the abraded metal surface [25−27].

In our study, we used primers for metal, which were recommended by the producer, for connecting the titanium surface of the abutment and the restoration casted in CoCrMo alloy. Monobond Plus was used in combination with the Multilink Implant cement, which is the mediator of the bond which contains three different function groups dissolved in ethanol as a solvent: silane methacrylate, phosphoric methacrylate and sulfide methacrylate, out of which phosphoric methacrylate is responsible for improving the adhesion of the cement onto the metal surfaces of non-precious alloys. Metal Primer II, which was used in combination with the other examined cement, GC LINK Ace, contains a special monomer (MEPS: tiophosphoric methacrylate), which improves the bond of acrylate and composite for all kinds of metals. By comparing the results for the Multilink Implant and GC LINK Ace, for all four experimental groups, significantly greater retention force is recorded in samples, in which the corresponding metal primer is used. Therefore, a great retention value appears, mainly from the chemical adhesion of primer for the abutment metal and titanium abutment (primarily titanium dioxide). Dudley and associates came to similar results [28,29]. Examinations, which were done in the initial phase, 24 hours after cementing and 10000 cycles, point to the fall of the retention force for 1/3 of the value. The greatest fall of the retention force happened in the first week of function, and further fall of the bond value during time was slight. Dudley and associates examined the retention force of the Panavia F composite cement, by exposing the samples to the mechanical cyclical load of 192 cycles (1 week of function), 5000 cycles (6 months of function) and 10000 cycles (1 year of function), according to which it comes to the significant fall of the average retention value after 192 cycles, whereas the later increase of load quantity does not lead to further statistically significant fall of the average value (average retention value for 192, 5000 and 10000 cycles is not statistically significant from each other). If we observe the obtained results for the composite cements, used with the primers for metal, in the light of clinical application, then the cemented crowns, which stay cemented for implant abutments for a short period of time, and if some impeding factors appear, can, as expected, stay cemented for a long time without further significant fall of the retention bond. This fact points to the significance of the correct protocol of cementing, including the application of adequate primers for metal with the aim of improving the chemical bond quality. Disregarding the significant fall of the retention value of composite cements within all four experimental groups, which were observed for the period of one year, these cements show sufficiently big retention force, which can, in accordance with its still high values, provide the qualitative retention and stability of the restoration in function. Beside the usage of metal primers, some additional factors, which were proved in scientific studies, can participate in the obtained high value results. Analyzing the effect of primers on the composite bond quality must be more complex, if we take into consideration the fact that these adhesives, which were used for the bond of composites and metal, are exposed to constant stress in the oral cavity. In that sense, the simulation of the high degree of humidity, thermal stress and masticatory load is necessary, due to the reproduction of conditions in the oral cavity, in order to get exact data about the long-lasting efficiency of metal primers in connecting composites and metal in real conditions [30,31]. Due to the above mentioned reasons, all the mentioned conditions were simulated in the study during one year of function. Retention values of the examined composite cements after the simulation of one year of function decrease on average for 1/3 of value, which is sufficiently high value of force, which provides stability and retention to the restoration in function. Further researches with a prolonged period of simulation are necessary, in order to examine final values of these cements. Results from other studies contribute to good adhesion, which Multilink achieves with different surfaces.

The study, which was performed by Ergin and associates in 2002, showed that a potential chemical bond of the Multilink Implant for the smooth surface of the titanium abutment provided lesser retention than the combination of chemical adhesion (Monobond Plus) and micromechanical retention, which was provided by abrasion of the inner surface of the restoration [32].

High retention values of the composite cement used in the combination with primer can be in direct relation with the type of alloy, from which the bonding surface was made. Studies proved that the retention force value falls with the increase of the preciousness of alloy [33]. Almilhatti and associates found that the bond of the composite cement and titanium is 1.5 times higher in comparison to that one in precious alloys. These values can be connected with greater ability of titanium to oxidize. Micromechanical retention participates a lot more than chemical bond. Almilhatti and associates compared the strength of the composite cement bond with smooth, polished surface and surface which was abraded with 50 and 250 micron-sized particles of Al_2O_3. The strongest bond was found in surfaces abraded with 250 Al_2O_3 micron-sized particles. This is a significant fact for our study because the inner surface of the crown is abraded with 50 micron-sized Al_2O_3 particles, which leads to the conclusion that better retention could be achieved with particles made of bigger granules [34]. Besides, there are proofs that chemical affinity of phosphoric groups for aluminium oxide particles imprisoned on the metal surface after abrasion, can also participate partly in the efficiency of different primers. Ohkubo and associates with the help of EDS analysis, proved that oxygen and the remaining aluminium particles can be detected on the abraded surface of metal [35]. Titanium surface of abutment and the inner surface of the restoration abraded with aluminium particles, which were made of non-precious alloy, can be one of the significant factors, which beside primers, take part in accomplishing the high retention force measured in the study. However, the influence of aluminium on the bonding mechanism has not been examined well yet. Cobb and associates described changes on the surface morphology of gold alloys in comparison to differences in particles size and the value of pressure during abrasion. They found a higher concentration of aluminium on the surface of the abraded metal and the possibility of aluminium chemical affinity for functional monomers and phosphoric derivatives [36,37].

Taira and associates think that explanation can be searched in the oxide layer, with which the titanium surface is covered and which reacts with monomers from the phosphoric or carboxylic acid [38,39]. Some studies, which examined the marginal integrity in composite cements, pointed to the problem of marginal disintegration due to the exposure to humidity [4]. However, these results should be accepted with caution, because one should take into consideration the fact that a lot of studies, which examined the influence of humidity on composite cements, came to the conclusion that physical qualities of the cement decrease slowly and proportionally to the length of stay in a humid environment. [40,41].

In our study, all samples were exposed to humid conditions for a short period of time (24 hours after cementing), and therefore, one should take into consideration the possibility that in real, clinical conditions, due to the constant, long-lasting exposure of the restoration to the humid conditions of the oral cavity, the retention force would be smaller than this obtained in in-vitro laboratory conditions. Also, if the samples were not exposed to humidity, retention values could be higher than those observed in this study, and therefore, the results of different studies, which did not have identical conditions in in-vitro experiments, should be observed and compared very carefully. Practically speaking, after cementing in the oral cavity, a small amount of the cement, in the area of the marginal edge, is exposed to humid conditions. It is understandable that the problem becomes bigger when the marginal leaning is compromised and greater surface of the cement exposed, thus increasing the possibility of humidity penetration between the cement and abutment, which additionally reduces the cement retention and shortens the time of cement aging. Chemical polymerization of this cement enables fixation of metal and metal-ceramic fixed restorations, but it demands close adhesion of contact surfaces. In an attempt to explain the character and quality of the bond of this composite cement with surfaces of different characteristics after thermocycling, Bhandari with associates examined the bond quality, taking the micro-porosity as a parameter. Results have shown that between three examined cements (self-bonding composite Multilink cement, dual-polymerizing composite cement Adhesive bridge and conventional glass ionomer cement GC Fuji), the Multilink cement showed the smallest degree of micro-porosity, while bigger porosity was recorded on the connection of the cement with metal surface than on the connection of the cement and tooth surface, which is logical regarding the adhesion mechanism of the composite cement. However, this difference was not statistically significant, but it points to the need for improving the bond quality of the cement with metal and the need for introducing the metal primers into the protocols of cementing [42]. Factors, which can take part in the value of composite cement bond quality, are polymerization shrinkage and the high coefficient of thermal expansion. These stresses can lead to the formation of marginal hole and to the loss of qualitative bond. Davidson emphasized the significance of establishing the qualitative initial adhesion bond because polymerization shrinkage appears immediately, during the polymerization, whereas the hygroscopic expansion, which should compensate for it, demands hours, even days. If the adhesion is compromised during the cement polymerization, not every hygroscopic polymerization can compensate for the formed hole [43]. In our study, before the examination the samples were stored for 24 hours in physiological solution and we assume that this storage in the watery environment, although it lasted shortly, led to the relaxation of the internal polymerization stress in the early phase, through hygroscopic polymerization. Probably, this factor, at least partially, took part in the high initial retention force of the composite cement.

Most of the factors, which contribute to the final bond quality of the composite cement with the metal surface and abutment, can be promoted by improving the initial adhesion, in whose base there is the usage of bond supporters, that is, metal primers, beside strictly controlled conditions of cementing.

5. CONCLUSION

Masticatory load, humidity and temperature changes lead to the fall of the composite cement retention, which is used for cementing the restoration with metal base on the titanium abutment. The greatest fall of the retention force happens seven days after cementing, which emphasizes the significance of respecting the controlled conditions of cementing. Disregarding the proved retention fall to the 2/3 of the initial value after the first year of function, the strength of restoration bonding is still sufficient to provide the stability of the restoration in function. Further examinations, with the increase of the period of simulated aging, are necessary for examining final limits of the composite cement. The results of this in-vitro research show that the usage of chemical bond supporters combined with mechanical retention, improve bonding between the composite and titanium. We can conclude that doctors can take into consideration the usage of techniques, which combine chemical bond and mechanical retention when the reliable bond between the surface of the metal and composite is needed, which is the situation that we often meet in implantoprosthetics in clinical practice.

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АНАЛИЗА УТИЦАЈА МЕХАНИЧКИХ ОПТЕРЕЋЕЊА, ТЕМПЕРАТУРНИХ ФЛУКТУАЦИЈА И ХЕМИЈСКИХ ФАКТОРА НА КВАЛИТЕТ ВЕЗЕ КОМПОЗИТНОГ ЦЕМЕНТА СА ТИТАНИЈУМСКИМ И CoCrMo КОМПОНЕНТАМА ИМПЛАНТОПРОТЕТСКИХ СИСТЕМА – *IN VITRO* СТУДИЈА

Сажетак: Увод: Цементи су у усној дупљи изложени бројним стресовима који утичу на ретенцију цемента, при чему су најзначајнији мастикаторно оптерећење и температурни стрес. Златни стандард у процесу цементирања надокнада у савременој имплантопротетици представљају композитни цементи и њихова подложност утицајима фактора усне дупље значајан је фактор успјешности имплантопротетске терапије.

Материјал и метод: У оквиру истраживања је коришћено 40 експерименталних модела сачињених као комбинација оригиналних дијелова Nobel Biocare система (имплант реплика Nob Rpl NP и титанијумска супраструктура Easy abatment NP 0,75) и надокнаде изливене од CoCrMo легуре. Узорци су подијељени у четири експерименталне групе са по 10 узорака. Узорци сваке групе цементирани су различитим композитним цементом са или без примјене прајмера за метал. Прва група – Multilink Implant, IvoclarVivadent, Liethenstein, II група – Multilink Implant, IvoclarVivadent, Liethenstein + Monobond Plus, III група G-CEM LinkAce®, IV група - G-CEM LinkAce® + GC Metalprimer II. Узорци су похрањени 24 сата у условима 100% влаге, након чега је унутар сваке групе извршено пет кругова тестирања. Узорци су изложени циклусима термоциклирања и механичких цикличних оптерећења, чији је број одговарао периоду симулације функције у усној дупљи (неоптерећени узорци, седам дана функције, три мјесеца, шест мјесеци и 12 мјесеци). Ретенциона сила мјерена је у универзалној машини за кидање.

Резултати: Највиша вриједност композитног цемента забиљежена је при иницијалном мјерењу, након чега опада са наредним круговима тестирања. Највећи пад се биљежи у првих седам дана након цементирања, док међусобна поређења наредних кругова тестирања не показују статистички значајне разлике. Вриједност ретенционе силе композитног цемента годину дана након цементирања пада за једну трећину почетне вриједности. Све забиљежене вриједности су више код узорака код којих је употребљен прајмер за метал.

Закључак: Мастикаторне силе и промјене температуре у усној дупљи доводе до пада ретенционе вриједности композитног цемента, али њена вриједност након годину дана функције још увијек је висока и омогућава стабилност и ретенцију надокнаде у функцији. Употреба прајмера за метал значајно утиче на вриједност силе ретенције на свим нивоима тестирања.

Кључне ријечи: имплантопротетика, композитни цементи, ретенција, механичко циклично оптерећење, температурне флуктуације, прајмери за метал.

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