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TIGHTNESS OF THE CONICAL IMPLANT-ABUTMENT INTERFACE

NEPROPUSNOST SPOJA KONUSNOG IMPLANTA-SUPRASTRUKTURE (ABUTMENTA)

Originalni naučni rad / Original scientific paper
Rad primljen / Paper received: 07.07.2022
https://doi.org/10.69644/ivk-2024-02-0139
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Keywords
- dental implant
- tightness
- conical connection
- abutment
- simulation complex

Abstract

Dental implant-based structures actively interact with the oral cavity and are subject to various factors. Local changes in the microflora near the implant can cause inflammation and affect its viability, as well as in the tooth. Improperly manufactured construction can also serve as a factor in the development of dysbiosis. The purpose of our study is to explore the permeability of the conical joint of the implant with an abutment of various types of manufacture under the influence of masticatory load.

The tightness of the conical joint is studied on MIS C1 implants, a standard platform. The control group of the study consists of standard transgingival abutments. As an experimental group were used: milled, cast, and obtained by laser sintering. Modelling of oral cavity conditions was studied in a simulation complex.

After 3000 masticating cycles the implant shafts were explored. When examining the inner surface of implants on which standard and milled abutments are fixed, the presence of methylene blue was not detected. A study of the implants shafts on which abutments were fixed, obtained by casting and laser sintering, showed the permeability of these compounds through the implant-abutment interface.

Use of original elements in the system ensures a hermetic implant-abutment connection. In complex clinical cases for treatment and rehabilitation of patients, the manufacture of structures with individual abutments is required. The best result is achieved using abutments made by milling.

Ključne reči
- zubni implant
- nepropusnost
- konusni spoj
- suprastruktura (abutment)
- složena simulacija

Izvod

Konstrukcije tipa zubni implanti aktivno deluju na usnu šupljinu i podložne su raznim uticajima. Lokalne promene u mikroflori u okolini implantata mogu izazvati upalu i uticati na njegov integritet, kao i na zub. Nepropisno proizvedena konstrukcija takođe može uticati na razvoj disbioze. Svrha našeg rada je istraživanje propusnosti konusnog spoja implanta sa abutmentima različitih tipova izrade pod uticajem opterećenja maseteričnog sistema.

Nepropusnost konusnog spoja proučava se na MIS C1 implantima, kao standardnoj platformi. Kontrolnu grupu istraživanja čine standardni transgingivalni abutmenti. Kao eksperimentalna grupa upotrebljeni su: brušeni, liveni, i abutmenti dobijeni laserskim sinterovanjem. Modeliranje stanja usne šupljine proučava se u složenim simulacijama.

Nakon isteka 3000 ciklusa žvakanja istražena je osovina implantata. Pregledom unutrašnje površine implantata, gde su fiksirani standardni i brušeni abutmenti, nije otkriveno prisustvo jedinjenja metilensko plavo. Istraživanje osovina implantata sa fiksiranim abutmentima, dobijenih livenjem i laserskim sinterovanjem, pokazalo je propusnost ovih spojeva kroz interfejs implant-abutment.

Korišćenje originalnih elemenata sistema obezbeđuje hermetičnost spoja implant-abutment. U složenim kliničkim slučajevima za lečenje i rehabilitaciju pacijenata, neophodna je proizvodnja pojedinačnih konstrukcija abutmenta. Najbolji rezultati se postižu sa abutmentima izrađenim brušenjem.

INTRODUCTION

The use of dental implants is an option of choice as a replacement for various defects of the dentition, /1/. Dental implant-based structures actively interact with the oral cavity and are subject to various factors, /2/. The oral cavity is not sterile, it contains more than 700 microorganisms, /3/. They form the microflora of the mouth, /4/. The creation of high-quality structures and adequate oral hygiene do not critically change the composition of the microflora, /5, 17, 18/. Under certain conditions (human diseases, taking antibiotics, etc.), one type of microorganisms may prevail over another /6-12/. Local changes in the microflora near the implant can cause inflammation and affect its viability, as well as in the tooth, /13, 14/. An improperly manufactured construction can also serve as a factor in the development of dysbiosis, /15, 16/.

The design of dental implants consists of several parts: crown, abutment, implant and fixing screw (Fig. 1), /19/. Each element must be hermetically connected, preventing the penetration of mouth contents (saliva, food particles, microorganisms), /20/. The use of standard prosthetics allows you to achieve this result. But not in all clinical cases is it possible to use factory suprastructures, /21/. Abutments can be made in various ways. However, the clinical efficacy has been poorly studied. The purpose of our study is to explore the permeability of the conical joint of the implant with abutments of various types of manufacture under the influence of masticatory load.

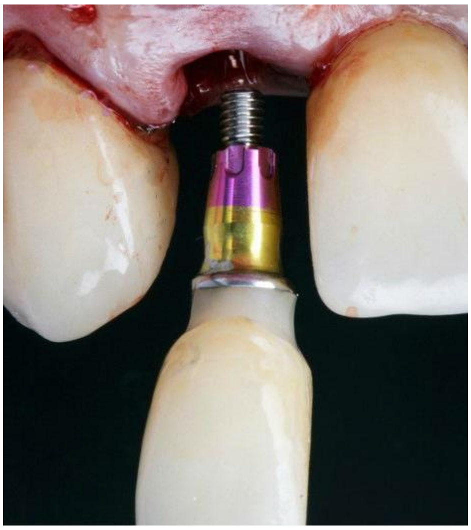

Figure. 1. Crown on the abutment is fixed to the implant by a screw.

MATERIALS AND METHODS

The tightness of the conical joint is studied on MIS C1 implants, a standard platform. This system has a conical connection. Inside the implant there is a hexagonal positioner that prevents scrolling along the axis of the structure (Fig. 2).

Figure. 2. MIS C1 implantation system components.

The control group of the study consists of standard transgingival abutments in the amount of 3 units, (Figs. 3 and 4). As an experimental group, 9 individual abutments with an antirotational element are used, manufactured in various ways: milled, cast, obtained by laser sintering (Figs. 5-10).

Figure. 3. A group of standard transgingival abutments for cement fixation, which was used in the study.

Figure. 4. A standard transgingival abutment has a conical interface with an antirotational part (highlighted in purple).

Figure. 5. Individually made abutments by milling.

Figure. 6. Surface of the conical interface of a milled abutment.

Figure. 7. A group of abutments obtained by selective laser sintering (SLS).

Figure. 8. Surface of the conical interface of the SLS abutment.

Figure. 9. A group of abutments obtained by casting.

Figure. 10. Surface of the conical interface of the cast abutment.

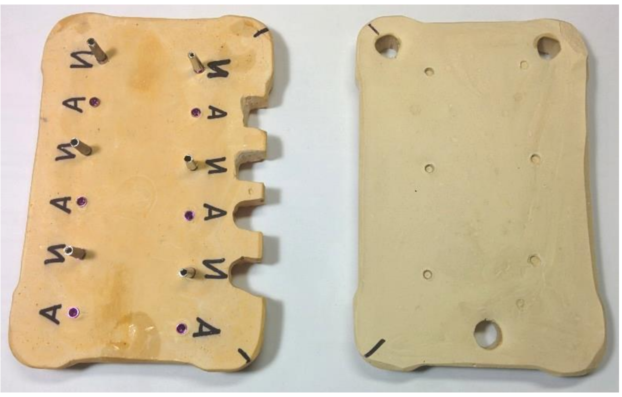

Figure. 11. A plaster block made of class 4 gypsum with implants (a), and a mate (b).

A block of class 4 gypsum with fixed implants at right angles to the surface was previously made. The implant shaft and the surface of abutments were degreased with Anhydrin VladMiVa solution and dried with an air jet. The screws of the abutments were tightened with a torque of 30 Ncm, according to the manufacturer's recommendation. In order to investigate the penetration only through the joint and exclude liquid penetration through the screw hole, the shaft was closed with a Teflon™ tape (insulated the screw and served as a marker for liquid penetration) and liquid-flowing composite DentLight VladMiVa with subsequent polymerization. An additional block of gypsum of the 1st class was made (Fig. 11) based on the prints of the fixed abutments. It is necessary that the applied pressure is distributed to all abutments simultaneously and evenly. The modelling of oral cavity conditions was studied in a simulation complex (Fig. 12), /22/. An essential feature of this utility model is that the design of this device allows the lower jaw frame to move using an electric motor, which reproduces the closing and opening of the jaw models. The device is capable of reproducing lateral occlusion, both left and right, due to the shift in the corresponding direction of the unequal angles on which the lower jaw frame is fixed. The upper jaw model has the ability to change its position in space in the sagittal and frontal planes. The pressure exerted on the jaw models can change due to an increase or decrease in the length of the connecting rod which is recorded by strain gauges. The apparatus in this study performed the following functions: create a masticatory load (within 20 kg) and a temperature change within 20-60 °C. To determine the permeability of the compound, a saline solution tinted with methylene blue is used. The tightness of the joint is determined by its presence in the implant shaft. The presence of the dye is determined using absorbent paper pins of the 35 taper (Fig. 13)

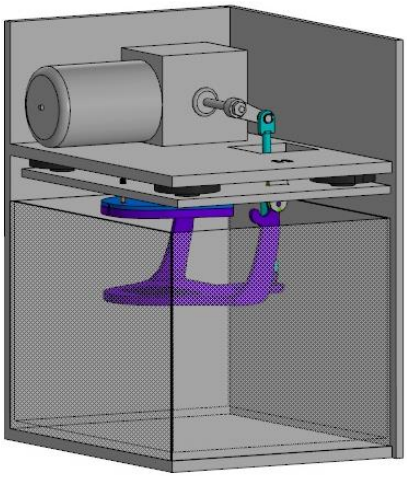

Figure. 12 Simulation complex.

Figure. 13. Paper adsorbing pins of the 35 taper.

RESULTS

After the expiration of 3000 masticating cycles, the plaster block was washed under running water and dried to avoid the dye getting inside the implant after the experiment. The abutment shaft was freed from the liquid-flowing composite. In all abutments, the Teflon™ tape turned out to be unpainted with methylene blue. This indicates the reliability of the study, in which case the presence of dye in the implant shaft will indicate possible permeability through the implant-abutment interface.

When examining the inner surface of implants, where standard (Fig. 14) and milled abutments were fixed, the presence of methylene blue was not detected (paper pins remained dry and unpainted after touching the implant shaft).

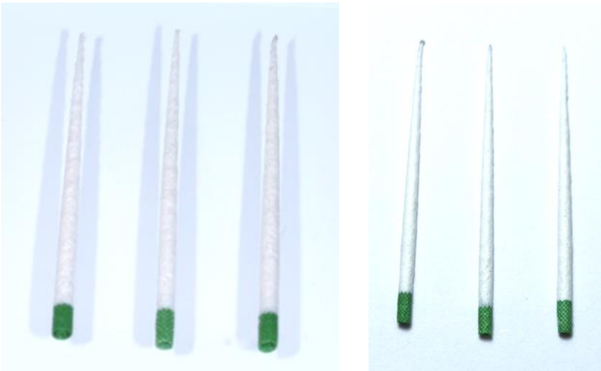

Figure. 14. Paper pins after examining the implant shafts with fixed standard (left) and milled (right) abutments - the ends were not stained with dye.

A study of the shafts of implants on which abutments obtained by casting and laser sintering were fixed showed the permeability of these compounds through the implant - abutment interface (Fig. 15). Moreover, there was more liquid with dye on adsorbing paper pins after the implant with a sintered abutment than with the cast one.

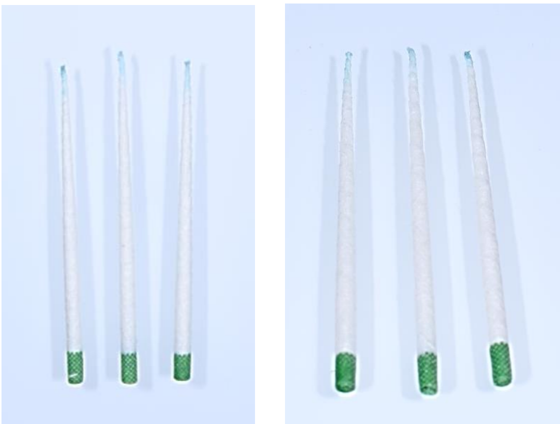

Figure. 15. The ends of paper pins were painted methylene blue after examining the implant shaft with fixed SLS (left) and cast (right) abutments.

The surfaces of standard and milled abutments remained without visible changes. With an increase in the outer cone of the milled abutments, there is a slightly noticeable groove remaining after milling (Fig. 6). However, the presence of such a defect did not affect the precision of the abutment cone and the inner cone of the implant.

The cone of the abutment after casting was manually refined by grinding and polishing. In this regard, the precision of the outer cone of the abutment and the inner cone of the implant was violated. When studying the cone surface under magnification, the presence of shells was revealed (Fig. 10). The abutments themselves were made in a manufacturing line with a manufacturing technique used for all products.

When considering the outer cone of the SLS abutment, the dye is determined. With an increase of the surface under consideration, a rough surface with the presence of bumps and depressions is determined, which are formed by the SLS method (Fig. 8). Under cyclic loading, the solution with the dye through the channels entered the implant shaft. Also, the rough surface on the neck of the abutment (the distance between the edge of the implant and the orthopaedic structure) also has a rough surface, which can serve as an additional retention point for microbial contamination.

CONCLUSION

The use of original elements of the system ensures a hermetic connection of the implant-abutment, which eliminates microbial penetration into the internal space of the implant. However, in complex clinical cases, it is impossible to apply original structures. Then, for the treatment and rehabilitation of patients, the manufacture of structures with individual abutments is required. The best result in tightness is achieved using abutments made by milling. The use of methods such as casting and laser sintering leads to contamination of the inner surface of the implant. At the same time, it is impossible to guarantee the success of orthopaedic treatment by installing such structures based on dental implants without the use of additional methods. Improving the quality of SLS abutments can be achieved through post-processing on a milling machine. It is also possible to create tightness due to sealants for implants (e.g., GapSeal®, Hager & Werken, Germany).

REFERENCES

1. Elani, H.W., Starr, J.R., Da Silva, J.D., Gallucci, G.O. (2018), *Trends in dental implant use in the U.S., 1999-2016, and projections to 2026*, J Dent. Res. 97(13): 1424-1430. doi: 10.1177/0022034518792567
2. Zellmer, I.H., Couch, E.T., Berens, L., Curtis, D.A. (2020), *Dental hygienists' knowledge regarding dental implant maintenance care: A national survey*, J Dent. Hyg. 94(6): 6-15.
3. Aas, J.A., Paster, B.J., Stokes, L.N., et al. (2005), *Defining the normal bacterial flora of the oral cavity*, J Clin. Microbiol. 43(11): 5721-5732. doi: 10.1128/JCM.43.11.5721-5732.2005
4. Preza, D., Olsen, I., Willumsen, T., et al. (2009), *Diversity and site-specificity of the oral microflora in the elderly*, Eur. J Clin. Microbiol. Infect. Dis. 28(9): 1033-1040. doi: 10.1007/s10096-009-0743-3
5. Choudhary, S., Verma, N., Anand, S., et al. (2021), *Comparative evaluation of changes in microflora in delayed and immediate implant placement: An in vivo study*, J Pharm. Bioallied Sci. 13 (Suppl 1): S105-S108. doi: 10.4103/jpbs.JPBS_572_20
6. Read, E., Curtis, M.A., Neves, J.F. (2021), *The role of oral bacteria in inflammatory bowel disease*, Nat. Rev. Gastroenterol. Hepatol. 18(10): 731-742. doi: 10.1038/s41575-021-00488-4

7. Koliarakis, I., Messaritakis, I., Nikolouzakis, T.K., et al. (2019), *Oral bacteria and intestinal dysbiosis in colorectal cancer*, Int. J Mol. Sci. 20(17): 4146. doi: 10.3390/ijms20174146
8. Kitamoto, S., Nagao-Kitamoto, H., Hein, R., et al. (2020), *The bacterial connection between the oral cavity and the gut diseases*, J Dent. Res. 99(9): 1021-1029. doi: 10.1177/0022034520924633
9. De Luca, F., Shoenfeld, Y. (2019), *The microbiome in autoimmune diseases*, Clin. Exp. Immunol. 195(1): 74-85. doi: 10.1111/cei.13158
10. Pignatelli, P., Fabietti, G., Ricci, A., et al. (2020), *How periodontal disease and presence of nitric oxide reducing oral bacteria can affect blood pressure*, Int. J Mol. Sci. 21(20): 7538. doi: 10.3390/ijms21207538
11. Jiang, X., Zhu, Y., Liu, Z., et al. (2021), *Association between diabetes and dental implant complications: a systematic review and meta-analysis*, Acta Odontol. Scand. 79(1): 9-18. doi: 10.1080/00016357.2020.1761031
12. Oleynikova, V.S., Cherkasov, S.N., Fedyaeva, A.V. (2021), *Age dynamics of the need for outpatient medical care for conditions that determine the basic value of the need in women with the diseases of the circulatory system*, Science of the Young (Eruditio Juvenium), 9(4): 543-552. doi: 10.23888/HMJ202194543-552 (in Russian)
13. Shahabouee, M., Rismanchian, M., Yaghini, J., et al. (2012), *Microflora around teeth and dental implants*, Dent. Res. J (Isfahan), 9(2): 215-220. doi: 10.4103/1735-3327.95239
14. Larsen, T., Fiehn, N.-E. (2017), *Dental biofilm infections - an update*, APMIS, 125(4): 376-384. doi: 10.1111/apm.12688
15. Tamizifar, A., Bahador, A., Moharrami, M., et al. (2018), *Microflora of laboratory-customized dental implant abutments*, J Int. Acad. Periodontol. 20(3): 86-93.
16. Hatzimanolakis, P., Tsourounakis, I., Kelekis-Cholakis, A. (2019), *Dental implant maintenance for the oral healthcare team*, Compend. Contin. Educ. Dent. 40(7): 424-429.
17. Dhaliwal, J.S., Abd Rahman, N.A., Ming, L.C., et al. (2021), *Microbial biofilm decontamination on dental implant surfaces: A mini review*, Front. Cell. Infect. Microbiol. 11: 736186. doi: 10.3389/fcimb.2021.736186
18. Cheung, M.C., Hopcraft, M.S., Darby, I.B. (2021), *Dental implant hygiene and maintenance protocols: A survey of oral health practitioners in Australia*, J Dent. Hyg. 95(1): 25-35.
19. Ye, L., (2017), *Current dental implant design and its clinical importance*, Hua Xi Kou Qiang Yi Xue Za Zhi, 35(1): 18-28. doi: 10.7518/hxkq.2017.01.003 (in Chinese).
20. Baixe, S., Tenenbaum, H., Etienne, O. (2016), *Pénétration microbienne dans la connectique pilier-implant : revue de littérature (Microbial contamination of the implant-abutment connections : Review of the literature)*, Rev. Stomatol. Chir. Maxillofac. Chir. Orale. 117(1): 20-25. doi: 10.1016/j.revsto.2015.11.004 (in French).
21. Valsan, I.M., Pauna, M.R., Petre, A.E., Oancea, L. (2021), *Biologic and esthetic outcome of CAD/CAM custom ceramic implant abutment: A clinical report*, Maedica (Bucur), 16(1): 145-148. doi: 10.26574/maedica.2020.16.1.145
22. Ilyasov, V., Mitin, N., Mishin, D., et al. (2020), *Study of temporary fixation materials on single orthopaedic structures by simulating chewing load*, Struct. Integr. Life, 20(2): 165-168.

CALENDAR OF CONFERENCES, TC MEETINGS, and WORKSHOPS

November 5-8, 2024	2024 Int. Symposium on Structural Integrity (ISSI2024)	Songshan Lake, Dongguan, China	link
November 17-19, 2024	12th Annual Conf. of the Society of Structural Integrity and Life (DIVK12)	Belgrade, Serbia	https://www.divk12.com/
November 18-21, 2024	2nd IQ-ICF Conf. in Africa and Middle East, Processing, performance, and failure analysis of engineering materials	Luxor, Egypt	https://www.icf-egypt2024.org/
November 26, 2024	Workshop: Structural Integrity Enhancement for Wind Energy Applications: Challenges and Opportunities for Coatings and Surface Engineering	Conventry University, Coventry, UK	link
December 16, 2024	Workshop: Engineering Structural Integrity: A Vital Enabler for Net-Zero	Royal Academy of Engineering, London, UK	link
September 15-18, 2025	IGF28 - MedFract3, 28th Int. Conf. on Fracture and Structural Integrity – 3rd Mediterranean Conf. on Fracture and Structural Integrity	Catania, Italy and web	https://www.igf28-medfract3.eu/
May 18-20, 2026	ESIA18–ISSI2026 18th Int. Engineering Structural Integrity Assessment Conference (ESIA18) in conjunction with China Structural Integrity Consortium's Int. Symposium on Structural Integrity 2026 (ISSI2026)	University of Strathclyde, Glasgow, UK	https://fesi.org.uk/esia18-issi2026/