DOI:10.33667/2782-4101-2023-1-4-6

COMPARATIVE STATIC STRENGTH EVALUATION OF THE IMPLANT–ABUTMENT JOINTS IN DIFFERENT IMPLANT DESIGNS

A. A. Elkanov, A. A. Dolgalev, Y. A. Sergeev, V. M. Avanisyan

Stavropol State Medical University of the Ministry of HealthCare of the Russian Federation, Stavropol, Russian Federation

SUMMARY

Nowadays the problem of optimal restorative prosthetics on dental implants is of paramount importance for solving a number of clinically difficult cases and extends beyond the alternative treatment at the complete and partial adentia both on the upper and lower jaws. An essential factor here is understanding of the biomechanical behaviour of the implant-abutment interface, because an optimal implant-abutment interface simulates the biophysical behaviour of natural teeth and ensures the long-term function of the prosthetic restoration. The optimal method for assessing the implant-abutment junction is the static tensile strength method. The limit is determined by performing a single loading of the dental implant in the implant-abutment area.

The aim *of the study was to assess the implant-abutment deformation of demountable and non-demountable structures of the 4x10 cylindrical and cone-shaped dental implants with determination of their static strength limit.*

Materials and methods. *Two brands of dental implants have been chosen as the objects of research – cylindrical implant LIKO M 4x10 and cone-shaped implant LIKO M DG 4x10. A subject of the research is the ultimate strength of the implant-abutment unit of demountable and non-demountable abutment design.*

Results. *Static loading tests with estimation of the deformation limit of the implant-abutment unit were carried out along with the comparative estimation of the strength of demountable and non-demountable abutment constructions of dental implants of various shapes.*

Conclusion. *The carried out comparative analysis of the static strength makes it possible to optimise the process of prosthodontic treatment on dental implants taking into account the maximal limits of the loaded structures and to carry out the equilibrium load distribution.*

KEYWORDS: *dental implant, abutment, static testing, conical dental implant, cylindrical dental implant, implant-abutment unit.*

CONFLICT OF INTEREST. *The authors declare no conflict of interest.*

Funding. *Funding for the study was carried out from the personal funds of the authors.*

Introduction

Today, the issue of optimal restorative prosthetics on dental implants is of paramount importance in a number of clinically challenging cases and goes beyond alternative treatment for complete and partial adentia on both the upper and lower jaw. Understanding the biomechanical behaviour at the implant-abutment interface is essential, because an optimal implant-abutment interface mimics the biophysical behaviour of natural teeth and ensures the long-term function of the prosthetic restoration [3]. The optimal method for evaluating the implant-abutment junction is the static method for determining the strength limit [4–6]. The limit is determined by a single loading of the dental implant in the implant-abutment area [7–11].

The aim of the study was to assess the implant-abutment deformation of demountable and non-demountable abutment structures of 4x10 cylindrical and cone-shaped dental implants, with determination of their static strength limit.

Materials and research methods

Implementation of the implant-abutment unit strength limit by the level of the beginning of deformation was carried out in accordance with the protocol of strength tests of dental implants according to GOST R ISO 14801–2012 «Dentistry. Implants. Fatigue tests for intraosseous dental implants». [1, 2].

Demountable and non-demountable abutment structures with Lico-M and Lico-M DG 4x10 dental implants were chosen as objects of study for static tests of the implant-abutment unit (*Fig. 1*). The abutment was fixed with a torque wrench at 25 N*cm, taking into consideration the pre-tightening of the screw.

The static strength was assessed under single loading without consideration of load asymmetry. The abutment

A B

Fig. 1: Demountable and non-demountable abutment design: A) cylindrical abutments, B) conical abutments

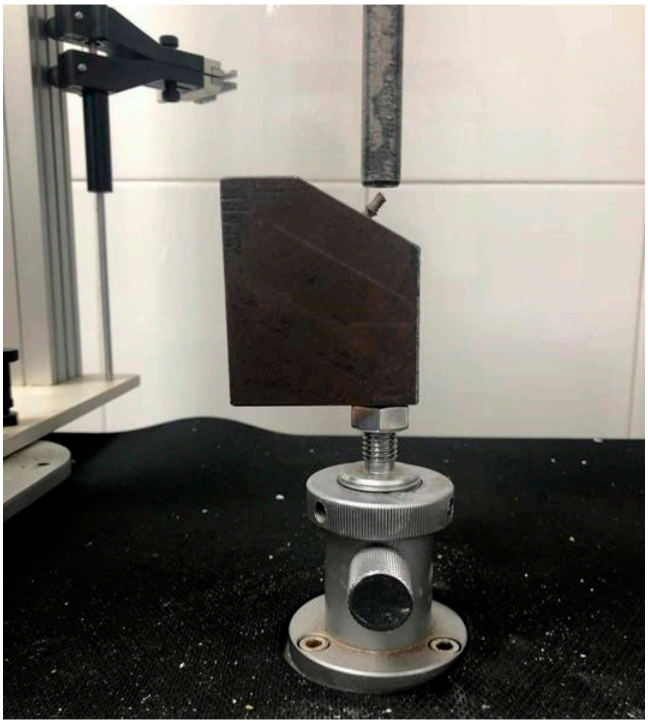

Fig. 2: Holder with fixed implant.

Table 1
Static test results of the implant-abutment connection.

No. n/a	d, mm	Sample No.	F max, N	Place of destruction
1.	4,0	1	698	screw
2	4.0	2	696	screw
3	4.0	3	642	screw
4	4,0	4	631	screw
5	4,0	5	657	screw
6	4.0	6	682	screw
7	4.0	7	858	Abutment
8	4,0	8	962	Abutment
9	4.0	9	1150	Abutment
10	4.0	10	1042	Abutment
11	4,0	11	978	Abutment
12	4,0	12	996	Abutment

and implant were fixed in the holder with a photopolymerizable composite to match the axis of force application (*Fig. 2*). The load was applied by means of a flat loading device to a hemispherical element secured to the abutment with a screw.

The static strength of the implant-abutment connection was determined using the Gotech-AI7000S testing machine (*Fig. 3*).

Results

The results were determined based on the initial structural displacement under static loading in order to determine the limits of the implant-abutment assembly (*Table 1*).

Based on the static strength analysis of the implant-abutment connection, the static strength results of the non- demountable constructions were optimal, as the average strength values were 997 N compared to the demountable ones, 668 N (*Fig. 4*).

Fig. 3: GT-AI7000-S test machine.

In a comparative assessment of the dependence of implant-abutment margins on the shape of the dental implant, a correlation was established between non-displaced structures fixed on cone and cylindrical implants, with a mean value of 643 N for cone and 692 N for cylindrical implants (*Fig. 5*).

The values for the demountable abutment designs were similarly compared. For cone abutments, these values averaged 932.7N, and for cylindrical abutments, 1062.7N, reflecting the dependence of the limit values of the implant-abutment assembly on the shape of the dental implant.

Conclusions

In determining the implant-abutment connection limits among demountable and non-demountable abutment designs, it was found that the optimally high values were characteristic of the non-demountable designs. At the same time, the dependence of the implant-abutment strength on the shape of the dental implant was found to be lower for cone-shaped dental implants, both for demountable and non- demountable designs.

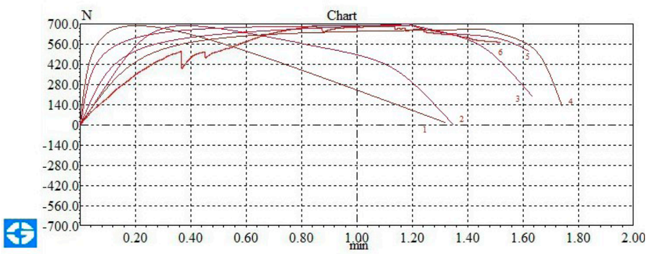

Fig. 4. Static test schedule for specimens with demountable abutment design

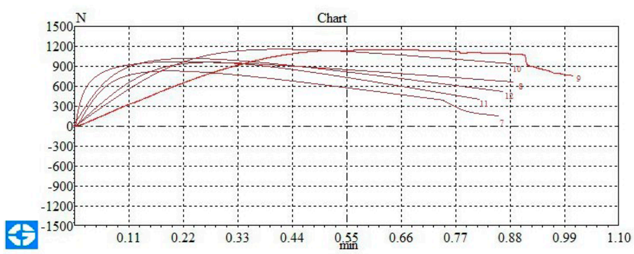

Fig. 5. Static test schedule for specimens with non-disassembled abutment design

References

1. *GOST R ISO 14801–2012. Dentistry. Implants. Fatigue tests for intraosseous dental implants.– M.: FGUP «STANDART-INFORM», 2012.– 12 c.*
2. *Muraev A. A. Innovative Russian system of dental implants: development, laboratory research and clinical implementation: specialty 14.01.14 «Dentistry». D. thesis for the degree of Doctor of Medicine / Muraev Alexander Alexandrovich.– Moscow, 2019.– 294 c.*
3. *Tsygankov Alexey Igorevich. «Modelling of Fatigue Failure of Intraosseous Dental Implants» Models, Systems, Networks in Economics, Engineering, Nature and Society, no. 3 (7), 2013, pp. 188–192.*
4. *Bayata F., Yildiz C. The effects of design parameters on mechanical failure of Ti-6Al-4V implants using finite element analysis. Eng. Fail. Anal. 2020; 110: 104445. doi:10.1016/j.engfailanal.2020.104445.*
5. *Duan Y., Griggs J. A. Effect of loading frequency on cyclic fatigue life of a standarddiameter implant with an internal abutment connection. Dent. Mater. 2018; 6: 1711–1716. doi: 10.1016/j.dental.2018.09.001.*
6. *John W. N. Titanium Alloys for Dental Implants: A Review. Prosthesis. 2020; 2: 100–116.*
7. *Leon P. P., Bartolome J. F., Lombardia C., Pradies G. Mechanical fatigue behaviour of different lengths of screw-retained restorations connected to two designs prosthetic connection level. J. Oral Rehabil. 2019; 46:747–755.*
8. *Sergeev Yu.A., Dolgalev A. A., Choniashvili D. Z., Avanisyan V. M. Application of the finite element analysis in the development of new dental implant systems. Medical alphabet. 2023;(1): 18–23. https://doi.org/10.33667/2078–5631–2023–1–18–23*
9. *Qian L., Todo M., Koyano K. Effects of implant diameter, insertion depth, and loading angle on stress/strain fields in implant/jawbone systems. Int. J. Oral Maxillofac. Implants. 2009; 24:877–886*
10. *Sun, F., Lv, L. T., Cheng, W., Zhang, J. L., Ba, D. C., Song, G. Q., & Lin, Z. (2021). Effect of Loading Angles and Implant Lengths on the Static and Fatigue Fractures of Dental Implants. Materials (Basel, Switzerland), 14(19), 5542. https://doi.org/10.3390/ma14195542*
11. *Wang K., Geng J., Jones D., Wei X. Comparison of the fracture resistance of dental implants with different abutment taper angles. Mater. Sci. Eng. C. 2016; 63:164–171. doi: 10.1016/j.msec.2016.02.015*

Received 10.03.2023
Revised 31.03.2023
Accepted 10.04.2023

INFORMATION ABOUT AUTHORS

Elkanov Akhmat Aubekirovich, *Candidate of Medical Sciences, assistant of the Departmentof Prosthodontic Dentistry, Stavropol State Medical University, Ministry of HealthCare of the Russian Federation, Stavropol, Russian Federation. SPIN-code: 2061–6616, Author ID: 1168427. Tel. +7-988-102-36-32, email: aha9107@yandex.ru*

Dolgalev Alexander Alexandrovich*, MD, Head of the Center for Innovation and Technology Transfer, Professor of the Department of General Practice Dentistry and Pediatric Dentistry of the Stavropol State Medical University of the Ministry of Health of the Russian Federation, Professor of the Department of Clinical Dentistry with a course of OS and MFS of the Pyatigorsk Medical and Pharmaceutical as Institute-branch of the Volgograd State Medical University, Stavropol, Russian Federation. ORCID: https://orcid.org/0000-0002-6352-6750. Tel. +7-962-440-48-61, email: dolgalev@dolgalev.pro*

Sergeev Yuriy Andreevich*, Postgraduate Student, Department of General Practice and Pediatric Dentistry, Stavropol State Medical University of the Ministry of Health of the Russian Federation, 355000, Stavropol, Russian Federation. ORCID: https://orcid.org/0000-0002-6183-2586. SPIN-code: 3007–8098, Tel. +7-906-440-18-89, email: serg_yuriy@mail.ru.*

Avanisyan Vazgen Mikhailovich*, 1st year resident at the Department of Therapeutic Dentistry, Stavropol State Medical University of the Ministry of Health of the Russian Federation, 355000, Stavropol, Russian Federation. ORCID: https://orcid.org/0000-0002-0316-5957, SPIN code: 1207–9234. Tel. +7-928-633-89-95, email: avanvaz@yandex.ru*

Contact person*: Yuri Andreevich Sergeev, postgraduate student of General and Pediatric Dentistry Department, 310 Mira St., Stavropol, Russian Federation. For correspondence: serg_yuriy@mail.ru, +7-906-440-18-89.*