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Comparative characteristics of the properties of dental implants depending on the design, shape and surface in the experiment

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SUMMARY

The aim of the study. Compare the properties of different dental implants depending on the design, shape and surface area in the experiment.

Materials and methods. Dental implants with similar sizes (5.5×10 mm) were selected: Vitaplant VPKS, Mega Gen AnyRidge and Alpha Dent Superior Active. The calculation of the total area of the implants was performed and the implants were immersed in a ferromagnetic substance.

Results and discussion. The small number of turns and their small length of the Vitaplant implant cannot create a large surface area (this size of the implant has an area of 174.7 mm^2).

On the thin, slightly conical body of the MegaGen implant (North Korea), the developer placed 10 turns of thread with wide blades. Due to the data design features, this implant has the largest surface area (276.5 mm^2), which is an advantage in implant integration.

The same number of turns (10) and a very similar frequency bring Alpha Dent implants (Germany) closer to the implant described above, but the design implements an innovative anti-rotation system. This implant size has a total surface area of 210.5 mm^2.

Conclusions. The implant Vitaplant VPKS is inferior in efficiency of the geometry of the implant Mega Gen AnyRidge by 24%, and the implant Alpha Dent Superior Active in turn ahead of the efficiency of the representative of the Korean company by 8.9%. The shape of the geometry of the implant affects the effectiveness of counteracting the masticatory load more than its surface area.

Keywords: shape of dental implant, efficiency of the geometry.

INTRODUCTION

The diversity and rapid development of modern dental implant systems with different types of surfaces, shapes and design features encourages practitioners to find their optimal mechanical and biological qualities. And the widespread use and availability of this method of restoring lost teeth creates an ever-increasing demand from patients (1,2,5). Unfortunately, some manufacturers prioritize the marketing appeal of their implant over research into the feasibility and biological benefits of a particular type of implant design and shape, and often simply duplicate or combine certain implant shape elements in well-known brands without understanding the developers' intent and goals. That is why the question of the optimal shape, the number of turns of the thread, the aggressiveness of the thread, the size of the thread blades, etc. cause a lot of contradictions and discussions and at the same time, remain relevant and little studied in the scientific literature. In this article, we compare popular implants and evaluate them from a new angle.

The aim of the study was to compare the properties of different dental implants depending on the design, shape and surface area of the experiment.

MATERIALS AND METHODS

For comparison, samples of currently popular in Ukraine dental implants of different manufacturers and price segments of the market but of similar

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Fig. 1. Vitaplant implant (Ukraine)

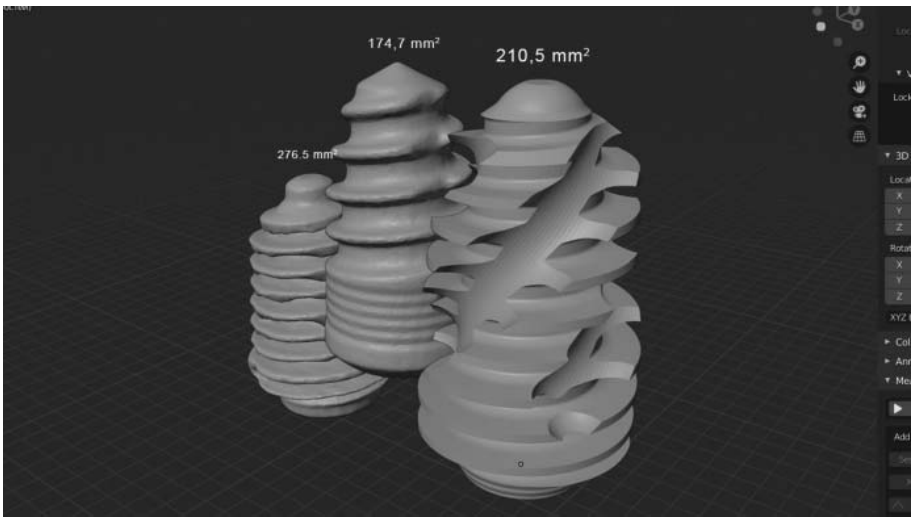

Fig. 2. Calculation of the surface area of implants by software method

sizes were selected, namely: dental implants Vitaplant VPKS 5.0×10 mm, dental implants Mega Gen AnyRidge 5.5×10 mm and dental implants Alpha Dent Superior Active 5.5×10 mm. These implants are positioned by manufacturers as optimal for single-stage implantation with the possibility of early or immediate loading. The calculation of the total area of the implants was performed by scanning the implants with an optical dental 3-D scanner DOF SWING at maximum resolution and software package Exocad Valletta and Blender.

During the experiment, the implants were immersed in a ferromagnetic substance with a constant coefficient of dynamic and kinematic viscosity at the same temperature conditions.

Statistical analysis was performed using SPSS 21.0 for Windows. The nonparametric Kolmogorov-Smirnov *Z* test was performed for data comparison between two groups.

RESULTS

Comparative characteristics of the most popular implant systems

Despite the influence of the implant shape on the primary stability and the distribution of oral loads, there is no standardization of implant design. There are dental implants on the market with different shapes. Based on literature sources, it was found that conical implants have a higher compression capacity than cylindrical ones.

The selected models of dental implants have a similar conical shape but differ sharply in the nature of design and surface shape, we have significant experience in the use of these implant systems, which allows us to adequately assess each of them. The Vitaplant implant (Ukraine) has a massive body and 5 equidistant turns of aggressive thread of insignificant length, moderately pronounced anti-rotation slots and the upper part of the body with often cut shallow turns designed for placement in the cortical layer of bone. This implant has all the hallmarks of versatility and is designed with bone types in mind. Aggressive thread, pronounced conicity of the body and pointed end allows you to develop a significant torque when installing the implant and guarantees a confident primary stability (Figure 1).

However, the small number of turns and their small length can not create a large surface area (this size of the implant has an area of 174.7 mm^2), which at an early load can cause disintegration of the implant, especially in case of prosthetics of molars. Also one of the debatable design solutions is a wide upper part with a small thread, which sometimes creates significant pressure in the cortical layer of the jaw bone and can provoke cracks and fractures of the walls in thin alveolar processes during implant placement and excessive bone recession in the future (Figure 2) (4).

The MegaGen implant (North Korea) is significantly different from the previous implant. On the thin, slightly conical body of the implant, the developer placed 10 turns of thread with wide blades. Due to the data design features, this implant has the largest surface area (of the implant systems described in this article, and is 276.5 mm^2 for this size), which is an advantage in both early and late stages of implant integration. Probably because of this, the manufacturer did not place any anti-rotation elements on this implant. The presence of extremely long threaded blades provides this implant with a number of significant advantages in practical application, and one of which is good primary stability in single-stage implantation, which is realized not by friction of the implant body, but by "cutting" the blades into the bone

structure (3). However, when implanted in a significantly corticalized jaw bone (type I bone) has to significantly expand the bed for the implant, which sometimes leads to a lack of contact of the bone with the body of the implant, may lead to a slight displacement of the implant during the engraftment stage (Figure 3).

Alpha Dent implants (Germany) have significant design differences. The body of this type of implant has a more natural smoothed shape, without sharp transitions, and apically ends with a rounded, the safest of the above, the top. The same number of turns (10) and a very similar frequency bring the Alpha Dent implant closer to the implant described above, but unlike the MegaGen and Vitaplant implants, the design implements an innovative anti-rotation system, which in our clinical experience and the results of the immersion experiment, provides this type of implants with unique opportunities to counteract the masticatory load without creating excessive pressure on the bone of the alveolar process, which in turn guarantees the prevention of bone recession in the neck in the first years of operation. Also, due to this special geometry of the surface of this implant, and a well-chosen balance between the length of the blades, the distance between them and the thickness of the implant body, it is possible to successfully use it load (6). This described implant size has a total surface area of 210.5 mm^2 (Figure 4).

We deliberately did not evaluate the surface quality of the implants described above, as this was not the purpose of our search, but this topic is of interest to us and may be explored by us in the future. The area of all implants differs slightly from the data stated by the manufacturer. We were able to find out that this is due to the fact that the manufacturer determines the area of the implant by a computer model of the implant, without taking into account the abrasive surface treatment, which in turn reduces -macro area but increases it at -micro level.

Thus, it can be concluded that at the present stage of development of implant systems, the integration of dental implants in bone tissue is obvious and highly predictable, and the demand of doctors and patients to reduce the number of surgical stages and reduce treatment time encourages manufacturers to find the most successful forms of implants. mechanical qualities at the smallest sizes. This circumstance inspired us to experiment with the dependence of the geometric shape of different implant structures and their ability to counteract the forces directed at immersion, ie, those that repeat the vectors of force application during chewing.

Experiment of the dependence of the geometric shape of different structures of dental implants and their ability to counteract the forces aimed at immersion.

Fig. 3. MegaGen implant (North Korea)

Fig. 4. Alpha Dent implants (Germany)

Table 1. Quallity assessment of articles using the Cochrane (RoB 2) tool

N	Vitaplant, sec	MegaGen, sec	Alpha Dent, sec
1	2.18	3.23	4.22
2	1.24	4.05	3.04
3	2.07	4.22	3.09
4	2.02	3.61	4.02
5	1.94	3.12	3.34
6	1.49	4.22	3.03
7	1.85	4.52	3.42
Average value	1.83	3.85	3.45

Statistical analysis was performed using SPSS 21.0 for Windows. The nonparametric Kolmogorov-Smirnov Z test was performed for data comparison between two groups. The significance level was determined at $p < .05$. The significant differences between the rates of implants' immersion were found. The rate of Vitaplant immersion statistically differs from MegaGen and Alpha Dent ($Z = 1.871$, $p = .002$ respectively). There were no significant differences regarding the immersion time of MegaGen and Alpha Dent ($Z = 0.802$, $p = .541$).

Table 2. Comparison of data on the immersion rate with the surface area of the implant

	Vitaplant	MegaGen	Alpha Dent
Surface area, mm^2	174.7	276.5	210.5
Average immersion speed, sec	1.83	3.85	3.45
The ratio of area to velocity	95.46	71.81	61.01
The efficiency of the geometry of the implant shape	1	1,24	1,36

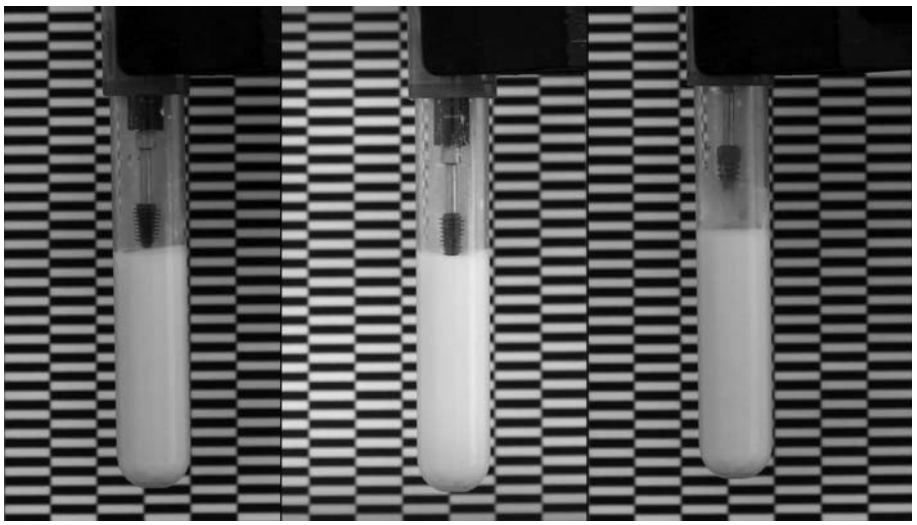

Fig. 5. The process of immersing dental implants in the ferromagnetic substance

It is obvious that the rate of immersion of a body in a substance with a constant coefficient of dynamic and kinematic viscosity at the same temperature conditions is equal to the force acting on this body and depends on its total surface area, geometric features of structure and weight. To objectify the experimental data, we immersed the implants as close as possible to each other in a viscous, elastic ferromagnetic substance, measuring the immersion time, which is a direct indicator of the resistance of gravity acting on them vertically. Obviously, the implant will accurately replicate the resistance while in the bone (Figure 5).

Implants with a larger surface area sink more slowly and this is obvious (Table 1). In order to distinguish from this experiment the role of surface geometry, we compared the data on the rate of immersion with the surface area of the implant.

According to the judgment that the best implant is that, which, having smaller dimensions, is able to withstand and distribute chewing pressure more rationally, the obtained coefficient (Table 2) demonstrates, in numerical equivalent, the effectiveness of implant's body geometric structure. It is logical to assume that the smaller coefficient of the ratio of implant's area to the speed of its immersion (RASI), the more efficiently it is built.

Conventionally, to compare the effectiveness of shape geometry of three types of implants, the 95.46 RASI coefficient Vitaplant was taken as the starting point of comparison – 1. Then other implants with lower RASI coefficients, when compared with it, got the values of 1.36 (Alpha Dent) and 1.14 (MegaGen) through simple arithmetic calculations.

DISCUSSIONS

The small number of turns and their small length of the Vitaplant implant can not create a large surface area (this size of the implant has an area of 174.7 mm^2).

On the thin, slightly conical body of the MegaGen implant (North Korea), the developer placed 10 turns of thread with wide blades. Due to the data design features, this implant has the largest surface area (276.5 mm^2), which is an advantage in implant integration.

The same number of turns (10) and a very similar frequency bring Alpha Dent implants (Germany) closer to the implant described above, but the design implements an innovative anti-rotation system. This implant size has a total surface area of 210.5 mm^2.

CONCLUSIONS

Based on the analysis of the data presented for comparison of implants and objective experimental data, the following conclusions can be reached:

- when choosing the size of the implant it is necessary to take into account not only the actual length and diameter, but also the surface area of the implant, which will be in contact with the receiving bed, so using this data can be used equally effectively smaller in size but the same size;
- the shape of the geometry of the implant affects the effectiveness of counteracting the masticatory load more than its surface area, so for the correct choice of the implant system it is necessary to have knowledge about the effectiveness of the geometry of the shape;
- when comparing the three implants of the above implant systems, with their approximate sizes, the implant Vitaplant VPKS 5.0×10 mm is inferior in efficiency of the geometry of the implant Mega Gen AnyRidge 5.5×10 mm by 24%, and the implant Alpha Dent Superior Active 5.5x10mm in turn ahead of the efficiency of the representative of the Korean company by 8.9%.

CONFLICT OF INTEREST

The authors declare no other potential conflicts of interest with respect to the authorship and/or publication of this article.

REFERENCES

1. Avetikov DS, Pronina OM, Stavytskyi SO, Buhanchenko OP. Оцінка косметичних результатів дентальної імплантації в зоні фронтальних зубів верхньої щелепи (Evaluation of the cosmetic results of dental implantation in the area of the frontal teeth of the upper jaw). Вісник проблем біології і медицини (Herald of problems of biology and medicine). 2016; 1 (4): 222-27.
2. Barbosa TP,· Naves MM, Menezes MHH, Pinto PHC, Mello JDB, Costa HL Topography and surface energy of dental implants: a methodological approach. J Braz. Soc. Mech. Sci. Eng. 2017; 39: 1895-1907.
3. Bathomarco RV, Solorzano G, Elia CN, Prioli R. Atomic force microscopy analysis of different surface treatments of Ti dental implant surfaces. Applied Surface Science 2004; 233, 1-4: 29-34.
4. Coelho PG, Granjeiro JM, Romanos GE, Suzuki M, Silva NRF, Cardaropoli G, [*et al.*]. Basic research methods and current trends of dental implant surfaces. J Biomed Mater Res B Appl Biomater. 2009 Feb;88(2): 579-96.
5. Kyrylenko S, Warchoł F, Oleshko O, Husak Y, Kazek-Kęsik A, Korniienko V [*et al.*]. Effects of the sources of calcium and phosphorus on the structural and functional properties of ceramic coatings on titanium dental implants produced by plasma electrolytic oxidation. Mater Sci Eng C Mater Biol Appl 2021;119:111607.
6. Mishchenko O, Solodovnik O, Oleshko O. Остеоінтеграція дентальних імплантатів з різними типами поверхні (Osseointegration of dental implants with external surface types). Буковинський медичний вісник (Bukovyna Medical Herald). 2020; 24,1 (93): 79-89.

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