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Comparative analysis of indicators of primary stability of implants of different implantological systems at immediate implantation

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SUMMARY

The aim of the study. Compare the primary stability indicators of implants from various implant systems.

Materials and methods. The study enrolled 27 patients; all participants underwent a surgical procedure involving tooth extraction accompanied by simultaneous one-stage dental implantation using Vitaplant VPKS, MegaGen AnyRidge, and Alpha Dent Superior Active implants. To assess primary stability during surgery (a torque test) was conducted. Additionally, the Implant Stability Quotient (ISQ) value was measured utilizing a Penguin RFA apparatus.

Results and discussion. Comparing multiple implants reveals a clear pattern and consistency within the torque range of various implant systems. This observation directly indicates the efficacy of their design and surface structure. The obtained data revealed distinct trends in ISQ progression over the 90-day period in patients with one-stage implantation of Alpha Dent Superior Active implants. The dynamics ISQ values from implantation of MegaGen AnyRidge demonstrated slightly regressive trend up to 21 days, followed by a rise in values from day 21. The overall pattern Vitaplant VPKS group resembles that of the previous implant groups, yet with slightly more scattered data.

Conclusions. The average indicators of primary implant stability (torque) across all implant systems fall within the range of 10 to 35 N/cm^2. No signifi cant statistical differences were observed among them. Nonetheless, it should be noted that Alpha Dent Superior Active implants exhibited a slightly higher torque value. The dynamics ISQ of MegaGen and Vitaplant implants demonstrate strikingly similar behavior, while the Alpha Dent implant displays a markedly accelerated healing process.

Keywords: squamous cell carcinoma, oral cancer, tobacco.

INTRODUCTION

In the adult population of most countries of the world, the prevalence of caries and its complications reaches 95-98% (1, 4, 5). If the patient goes to the dentist late, complications of the carious process lead to tooth loss and in some cases even to inflammatory diseases of maxillofacial area (8, 10). The contemporary need for rapid, yet comprehensive dental rehabilitation after ineffective conservative tooth treatment that meets the functional and aesthetic expectations of today's patients is compelling dentists to explore ways to meet these demands effectively. Dental implants have become a popular option for treating partially dentate or edentulous patients. Aiming to resolve the issue of a non-restorable tooth in a single visit by simultaneously extracting and implanting it, accompanied by immediate orthopedic loading, stands as a primary objective for numerous dental surgeons. This approach not only serves as validation of their expertise but also aligns with the growing desire for prompt dental care. However, achieving rapid tooth replacement demands meticulous preparation from both the surgeon and the manufacturer of the implant system

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(3, 9, 12). In contemporary implant procedures, the focus extends beyond adequate bone supply, ideal implant positioning, and surgical methods capable of achieving high torque upon placement. Equally crucial is the implant's capacity for rapid osseointegration or providing ample stability for early prosthetic attachment, particularly in instances involving immediate implantation following tooth extraction (7). This, in turn, requires the manufacturer to develop and improve the quality of the implant surface to facilitate the rapid course of biological processes and to develop unique types of implant shapes that will allow it to withstand significant mechanical loads immediately after implantation. That is why the search for and comparison of the qualities of different, constantly evolving implant systems to achieve the above goals prompted us to conduct this research. Using the torque test and measuring the ISQ indicators during dental implantation, we compared some popular implant systems (2, 12). The obtained data allow us to expand our knowledge of the processes of osseointegration of dental implants, enabling more reliable and expedited treatments for secondary anodontia. This paper presents the results of a comparison of the qualities of Vitaplant (Ukraine), MegaGen (Korea), and AlphaDent (Germany) implants in the conditions of immediate implantation.

The aim of the research is to compare the primary stability indicators of implants from various implant systems in cases involving tooth extraction and immediate dental implantation.

Objectives:

- Establishing the average indicators of primary implant stability (torque) during immediate implantation.
- Determining the mean values of ISQ (Implant Stability Quotient).
- Analyzing the dynamics of ISQ changes over 90 days.
- Conducting a comparative assessment of the collected data.

MATERIALS AND METHODS

The study enrolled 27 patients of different ages, genders and social backgrounds, each presenting two or more irreparable teeth or roots in both upper and lower jaws without signs of acute inflammation. All participants underwent a surgical procedure involving tooth extraction accompanied by simultaneous dental implantation using two different implant systems. Specifically, only molars from mandible were considered for comparison purposes.

For comparison, we selected samples of prevalent dental implants from diverse manufacturers and price ranges available in the current Ukrainian market, all sharing similar sizes and current popularity. Specifically, we focused on: Vitaplant VPKS 5.0×8 mm, MegaGen AnyRidge 5.5×7 mm, and Alpha Dent Superior Active 5.5×6.75 mm dental implants. These implants are marketed by their manufacturers as optimal choices for one-stage implantation, offering the potential for early or immediate loading.

To assess primary stability during surgery, a torque test was conducted, recording the resistance force during implant placement (measured in Newtons per cm^2). To determine the primary stability at the time of surgical intervention, we used the torque data obtained from a dynamometric wrench with a scale range of 10-40 N/cm^2 (step 5 N/cm^2), i.e., the value of the resistance of the bone structures of the jaw during implant installation was recorded. Additionally, the ISQ (Implant Stability Quotient) value was measured utilizing a Penguin RFA apparatus equipped with a standard multi-peg. During the dental implantation procedure, a gingival former was immediately placed in all cases. Subsequently, ongoing observation was carried out for 90 days, involving regular ISQ measurements every 14 days for further evaluation.

Statistical analysis was performed using SPSS 20.0 for Windows. The Paired-Samples T-test was performed for means comparison. The significance level was determined at $p \leq 0.05$.

RESULTS AND DISCUSSION

Establishing the average indicators of primary implant stability (torque) during immediate implantation.

We operated on 27 patients, each requiring simultaneous extraction of at least two molars due to various indications. Subsequently, at least two implants from different manufacturers were simultaneously installed (Figs. 1-4). During the implant placement, the resistance force of the implant (measured in Newtons per cm^2) was recorded, and the collected data is shown in Table 1.

The torque value plays a pivotal role in determining the placement of a gingival former and enabling early orthopedic loading (6, 12). While these values cannot solely serve as the primary criterion for assessing implant stability due to the inability to verify them in the future, comparing multiple implants concurrently in a consistent procedure within the same patient, coupled with diligent result documentation and statistical analysis, reveals a clear pattern and

Fig. 1. Atraumatic removal of teeth 46, 47, 48 with preservation of the cortical walls and interroot septum

Fig. 2. Simultaneous implantation of various implant systems

Fig. 3. Installation of gingival formers, condition after suturing of the wound

Fig. 4. State of the wound on the 14th day after the operation

consistency within the torque range of various implant systems. This observation directly indicates the efficacy of their design and surface structure.

Dynamics of ISQ changes over 90 days

In contrast to the torque values recorded during implantation, the observed changes in osseointegration dynamics (Implant Stability Quotient – ISQ), monitored at 14-day intervals over 90 days, provide a peculiar insight into the osseointegration process.

Remarkably higher ISQ scores were consistently recorded in patients with dental implants from the German company Alpha Dent Implants GmbH (Table 2, Fig. 5), setting them apart from other implant systems. This disparity can partly be attributed to the design of the standard multi-peg utilized with the Penguin RFA device, visibly demonstrating the best fit with the platform of this particular line of implants. However, our primary focus lies not in specific numerical values but in the dynamics of ISQ growth as a key criterion for evaluating the rate of osseointegration. Numerous researchers (9, 11) emphasize the significance of rapid osseointegration dynamics as a critical benchmark in comparing different implant systems. This swift dynamic signifies a successful structural and geometric design of the implant in conjunction with its surface microstructure.

The obtained data revealed distinct trends in ISQ progression over the 90-day period (Table 5). Notably, an initial rise in ISQ within the first 14 days (t=-5.060; df=17; p=0.000) probably indicates the effect of the spongeous bone straightening. Subsequently, from day 14 to day 21 (t=-1.566; df=17; p=0.136), a certain regression in the stability was noted, possibly indicating osteoclast activation and active restructuring of the bone matrix surrounding the implant. However, from days 21 to 45, a consistent and rapid increase in implant stability was observed (t=-11.690; df=17; p=0.000).

Table 1. The results of measuring of the resistance force (N/cm^2)

Name of implantological system	No. of patient								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
*Vitaplant	20	10	30	15	35	45	25	15	25
MegaGen	15	20	35	20	25	45	25	40	25
	10	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
**Vitaplant	25	10	30	25	10	30	20	30	25
Alpha Dent	15	10	30	20	15	40	25	30	25
	19	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
***MegaGen	15	20	20	35	30	30	25	30	40
Alpha Dent	20	25	20	30	30	45	35	25	35

* Between Vitaplant and MegaGen: t = –1,000; df = 8; p = 0.347.
** Between Vitaplant and Alpha Dent: t = –0.286; df = 8; p = 0.782.
*** Between MegaGen and Alpha Dent: t = –0.936; df = 8; p = 0.377.
No statistically significant differences in the value of the resistance force (torque) during simultaneous implantation were found.

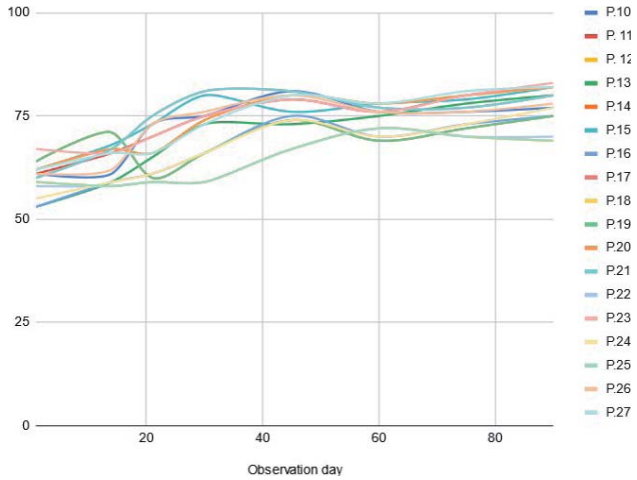

Fig. 5. Diagram of ISQ values obtained within 90 days in patients with one-stage implantation of Alpha Dent Superior Active 5.5×6.75 mm implants

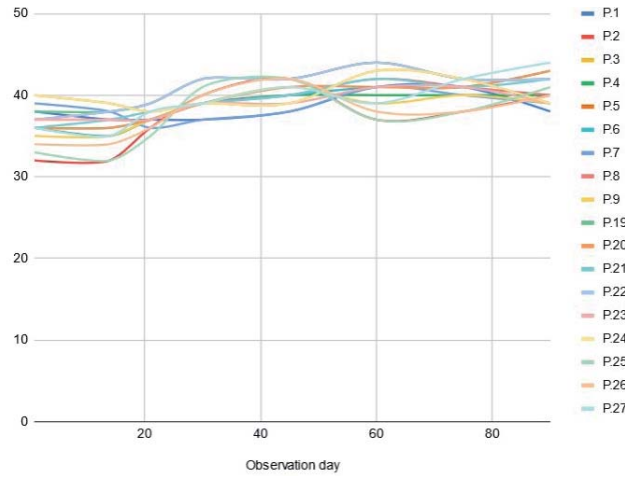

Fig. 6. Diagram of ISQ values obtained within 90 days in patients with one-stage implantation of MegaGen AnyRidge 5.5×7 mm implants

Table 2. ISQ values obtained during 90 days in patients with one-moment implantation of Alpha Dent Superior Active 5.5×6.75 mm implants

Day of observation	No. of patient																	
	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1	61	61	59	53	64	62	53	60	62	64	62	60	58	67	55	59	61	62
14	61	66	58	59	71	68	59	67	67	71	67	67	58	66	59	58	62	66
21	73	70	59	65	60	73	61	75	66	60	66	75	59	70	61	59	73	66
30	75	75	59	73	66	80	66	81	74	66	74	81	59	75	66	59	76	73
45	81	79	67	73	74	76	75	81	80	74	80	81	67	79	74	67	80	80
60	76	76	72	75	69	78	70	77	78	69	78	77	72	76	70	72	76	78
75	76	80	70	78	72	79	73	77	80	72	80	77	70	80	73	70	76	81
90	77	82	69	80	75	82	75	80	82	75	82	80	70	83	77	69	78	82

Table 3. ISQ values obtained during 90 days in patients with one-moment implantation of MegaGen AnyRidge 5.5×7 mm

Day of observation	№ of patient																	
	1	2	3	4	5	6	7	8	9	19	20	21	22	23	24	25	26	27
1	38	32	40	36	37	36	39	37	35	38	36	36	37	37	40	33	34	36
14	37	32	39	35	38	36	38	37	35	38	36	37	38	37	39	32	34	35
21	37	36	38	37	39	37	36	37	37	39	37	38	39	37	38	35	36	38
30	37	40	39	39	42	39	37	39	39	42	39	39	42	39	39	41	40	39
45	38	42	39	40	42	40	38	40	41	42	41	40	42	39	39	42	42	41
60	41	37	43	40	44	41	41	42	39	44	41	42	44	41	43	37	38	39
75	41	38	42	40	42	41	40	41	40	42	41	41	42	41	42	38	38	42
90	38	40	39	40	42	43	39	40	39	42	43	42	42	39	39	41	40	44

Table 4. ISQ values obtained during 90 days in patients with one-moment implantation of Vitaplant VPKS 5.0×8 mm

Day of observation	№ of patient																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	43	37	40	37	43	49	40	39	40	42	48	42	41	34	42	37	43	35
14	43	36	42	35	39	48	39	38	40	39	48	39	42	35	39	36	42	35
21	44	35	43	36	38	47	39	40	40	39	48	38	42	35	39	36	42	35
30	44	38	43	36	41	48	40	40	41	41	48	40	43	36	41	38	43	36
45	45	33	47	39	42	51	43	43	39	42	51	43	47	39	42	33	47	39
60	48	34	48	38	44	51	43	43	41	44	52	42	47	39	43	34	48	38
75	49	33	47	41	45	53	44	46	41	45	53	44	47	41	45	33	47	41
90	46	35	46	41	45	52	44	48	41	45	52	45	48	43	45	37	49	43

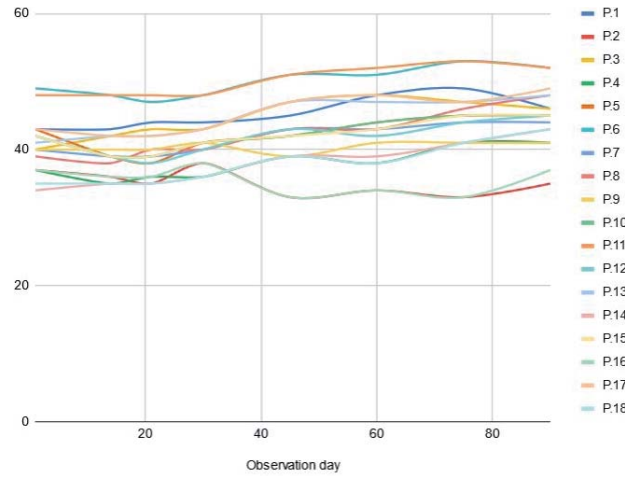

Fig. 7. Diagram of ISQ values obtained within 90 days in patients with one-stage implantation of Vitaplant VPKS 5.0×8 mm

This stage's pace substantiates the quality of interaction between the implant surface and osteoblasts, transforming the created protein matrix into partly mature bone tissue. The 45th to 60th day showed a slight decrease in ISQ (t=1.857; df=17; p=0.081), affirming the completion of osteoclast activity and the commencement of active mineralization in the forming bone. Finally, a gradual, steady increase in ISQ from day 60 to 90 indicated the ongoing maturation process (t=-4.377; df=17; p=0.000).

Table 3 and Figure 6 illustrate ISQ values from patients receiving one-stage implantation of MegaGen AnyRidge 5.5×7 mm implants. The dynamics observed here differ slightly from the Alpha Dent group (Table 5). A stable, slightly regressive trend was observed up to 21 days (t=-2.766; df=17; p=0.013), followed by a rise in ISQ values in all patients from day 21 to 45 (t=-7.795; df=17; p=0.000). Notably, the peak in values, occurring on day 60 (t = -0.728; df=17; p=0.477), possibly correlates with the wider thread body of the implant, requiring additional time for bone formation between turns. These dynamics align closely with data provided by the manufacturer in its studies, supporting the reliability of the recorded data.

Table 4 and Figure 7 present data obtained from Vitaplant VPKS 5.0×8 mm implants. The overall pattern resembles that of the previous implant groups, yet with slightly more scattered data. The graphical representation indicates a greater dispersion of data, suggesting that the implant surface geometry might exert less compression on the bone tissue compared to the previously described implant systems. In our opinion, the implant is not sufficiently "aggressive" and behaves less stable in bone biotypes I and II. Despite this, the data remains suitable for comparison, as the dynamics of ISQ values correlate closely with the preceding groups (Table 5).

CONCLUSIONS

Upon analyzing the aforementioned data, and after comparing various implant systems, the following conclusions can be drawn:

1. The average indicators of primary implant stability (torque) across all implant systems fall within the range of 10 to 35 N/cm^2. No significant statistical differences were observed among them. Nonetheless, it should be noted that under identical conditions, Alpha Dent Superior Active implants exhibited a slightly higher torque value. This observation aligns with the experiment investigation of the relationship between distinct geometric shapes of various dental implant designs and their capability to withstand forces directed at implantation.
2. The performance of implants placed within the same timeframe, under identical patient conditions, exhibited distinct behaviors, exposing the primary differences

Table 5. Differences in the value of ISQ changes during simultaneous implantation

Day of observation	Mean	Standard Deviation	Standard Error Mean	t	df	p-value
Alpha Dent						
1-14	-3,722	3,121	,736	-5,060	17	,000
14-21	-2,278	6,172	1,455	-1,566	17	,136
21-45	-9,833	3,569	,841	-11,690	17	,000
45-60	1,611	3,680	,867	1,857	17	,081
60-90	-3,278	3,177	,749	-4,377	17	,000
MegaGen						
1-14	,222	,732	,173	1,288	17	,215
14-21	-1,000	1,534	,362	-2,766	17	,013
21-45	-3,167	1,724	,406	-7,795	17	,000
45-60	-,500	2,915	,687	-,728	17	,477
60-90	,833	3,869	,912	,914	17	,374
Vitaplant						
1-14	,944	1,589	,375	2,521	17	,022
14-21	-,056	,802	,189	-,294	17	,772
21-45	-2,722	2,396	,565	-4,820	17	,000
45-60	-,667	1,138	,268	-2,486	17	,024
60-90	-1,556	2,007	,473	-3,289	17	,004

among various implant systems. Upon comparing the trends illustrated in Figure 8, it becomes evident that MegaGen and Vitaplant implants demonstrate strikingly similar behavior, while the Alpha Dent implant displays a markedly accelerated healing process. Notably, starting from similar initial positions, the latter significantly gains stability, maintaining these values between 45 to 90 days, with a slight regression but stabilizing at these levels. In our assessment, it is the unconventional implant shape coupled with an active hydrophilic surface (wet implant) that facilitated the activation of the osteoblast-osteoclast complex during the initial phases, consequently yielding these distinctive outcomes.

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. Ananieva MM, Faustova MO, Basarab IO, Loban' GA. Kocuria rosea, kocuria kristinae, leuconostoc mesenteroides as caries-causing representatives of oral microflora. Wiad Lek. 2017;70(2 pt 2):296-298.
2. Coelho PG, Granjeiro JM, Romanos GE, Suzuki M, Silva NR, Cardaropoli G, Thompson VP, Lemons JE. Basic research methods and current trends of dental implant surfaces. J Biomed Mater Res Part B: Appl Biomater. 2009; 88(2): 579-96. doi: 10.1002/jbm.b.31264.
3. Dayan C, Geckili O, Bural C. The Influence of Implant Shape on Primary Stability of Implants With a Thread Cutting and Forming Design: An Ex Vivo Study. J Oral Implantol. 2019; 45(3): 181-185. doi: 10.1563/aaid-joi-D-18-00158.
4. Faustova MO, Ananieva MM, Basarab YO, Loban' GA. Neutrophil bactericidal activity through the stages of placement of different dental implants depending on their chemical composition. Wiad Lek. 2017;70(5): 921-924.
5. Faustova MO, Ananieva MM, Basarab YO, Dobrobolska OV, Vovk IM, Loban' GA. Bacterial factors of cariogenicity (literature review). Wiadomosci lekarskie. 2018; 71(2): 378-382.
6. Geramizadeh M, Katoozian H, Amid R, Kadkhodazadeh M. Finite Element Analysis of Dental Implants with and without Microthreads under Static and Dynamic Loading. J Long Term Eff Med Implants. 2017; 27(1):25-35. doi: 10.1615/JLongTermEffMedImplants.2017020007.
7. Kaplun D, Avetikov D, Lokes K, Ivanyts'ka O. Comparative characteristics of the properties of dental implants depending on the design, shape and surface in the experiment. Stomatologija. Baltic Dental and Maxillofacial Journal. 2023; 25: 21-5.
8. Kostylenko YP, Talash RV, Bilash SM, Boyko IV, Bukhanchenko OP, Ivanytska OS. Morphological condition of the pulp of intact and affected by caries third molars. Reports of Morphology, 2020; 26(4): 48–54. doi: 10.31393/morphology-journal-2020-26(4)-08.
9. Kreve S, Ferreira I, da Costa Valente ML, Dos Reis AC. Relationship between dental implant macro-design and osseointegration: a systematic review. Oral Maxillofac Surg. 2024; 28(1): 1-14. doi: 10.1007/s10006-022-01116-4.
10. Lokes K, Lychman V, Izmailova O, Shlykova O, Avetikov D, Kaidashev I. Expression of periferal core molecular clock genes in oral mucosa depends on the chronotype in patients with maxillofacial cellulitis. J Oral Biol Craniofac Res. 2023 Sep-Oct;13(5):517-521. doi: 10.1016/j.jobcr.2023.06.001.
11. Moradi H, Beh Aein R, Youssef G. Multi-objective design optimization of dental implant geometrical parameters. Int J Numer Method Biomed Eng. 2021; 37(9): e3511. doi: 10.1002/cnm.3511.
12. Silva GAF, Faot F, Possebon APDR, da Silva WJ, Del Bel Cury AA. Effect of macrogeometry and bone type on insertion torque, primary stability, surface topography damage and titanium release of dental implants during surgical insertion into artificial bone. J Mech Behav Biomed Mater. 2021; 119: 104515. doi: 10.1016/j.jmbbm.2021.104515.

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