EFFECTIVENESS OF DENTAL IMPLANTATION WITH IMMEDIATE LOADING WHEN REPLACING FRONTAL DENTITION DEFECTS

Alexandr Lepilin[1] ✉ iD, **Maria Shalina**[1],
Nadezhda Erokina[1], **Natalia Zakharova**[1],
Sergey Fischev[2], **Arkady Sevastyanov**[2],
Yana Chernenko[1] iD, **Dmitry Domenyuk**[3,4] iD

[1] *Saratov State Medical University, Saratov;*

[2] *St. Petersburg State Pediatric Medical University, St. Petersburg;*

[3] *Stavropol State Medical University, Stavropol;*

[4] *Pyatigorsk Medical and Pharmaceutical Institute — Branch of the Volgograd State Medical University, Pyatigorsk, Russia*

✉ *lepilins@mail.ru*

ABSTRACT — Dental implantation, viewed as an independent research-based method used to treat patients with partial and complete adentia, has a special place among the major dental specialties. There are surgical algorithms and established methods for using dental implants available. The classical two-stage implantation protocol with delayed loading is considered the most reliable and predictable, featuring the lowest complication rate. The increased interest in direct dental implantation with immediate loading can be accounted for by psycho-emotional factors, accelerated implant osseointegration, better functional and aesthetic results, prevention of alveolar process bone atrophy, as well as reduced volume of surgical and orthopedic interventions. The stability of dental implants after direct implantation and immediate loading has been found to match the stability of implants after employing a two-stage technique. The primary stability of dental implants installed directly into the hole of the removed tooth on the anterior mandible is due to a small volume of spongy substance at a significantly thick cortical layer, possible installation of an implant with a length exceeding the length of the tooth root, the availability of a proper keratinized gum zone, as well as the removal from occlusion temporary structures on implants.

KEYWORDS — dental implantation, immediate loading, osseointegration, frontal mandible.

INTRODUCTION

Prosthetics on dental implants is currently considered as one of the most common orthopedic methods used to treat dentition defects of various lengths [3, 4, 20–22].

The standard two-stage implantation protocol takes 3–6 months right before prosthetics, which has a significant negative impact on the patient's life quality at the treatment stages. Direct prosthetics implying the installation of implants in the hole of a removed tooth or in the area of a long-missing tooth has been proven effective by positive clinical outcomes [6, 9].

The idea of im-mediate prosthetics involves the fixation of abutments and temporary crowns straight after the im-plants are installed. The requirements for direct prosthetics include good quality of the bone tissue (Type DI, DII type); possible installation of 10-16 mm long implants; available duly keratinized gum zone; possible removal from occlusion of the temporary prosthesis on implants. Single-stage implantation and direct prosthetics allow installing the implant in the hole right after the respective tooth was extracted, while achieving the stability of the implant will require its length exceeding the roots of the teeth, thus improving the intra- vs. extra-bone part ratio of the structure. The authors claim that the specifics of dental implantation in the chin part of the mandible are due not to lack of anatomical structures that complicate the installation, yet also to the lack of bone tissue required for implantation [5, 6, 9].

Arriving at a positive outcome of dental implantation will take considering the respective anatomical and topographic features [5], a thorough surgery plan, studying all possible ways to measure the implant stability [6], and due examination of the gingival sulcus cytokine profile at the installed implants [1, 2, 7, 8, 12–18]. Additional treatment, including medication, following dental implantation surgery, plays a significant role, too [6, 9–11].

The subject of the study focusing on the reliability of implants in case of direct installation in the upper jaw (palatine installation) and lower jaw (lingual installation) after removal of single-root teeth was the size, the topography of the installed implants, the stability, and the absence of pain and inflammation. As the authors found, direct implantation can offer predictable anatomical, functional and aesthetic results, regardless of the implant size and location, whereas their survival rate reaches 96% [19].

According to the reference literature the effectiveness of dental implantation in the frontal mandible

underlying various installation protocols has not been studied well enough.

Aim of the study:
to develop a surgical treatment algorithm forecasting possible immediate load on dental implants for improved dental implantation in the anterior mandible

MATERIALS AND METHODS

The study involved 83 patients (42 males and 41 females) aged 20–50, with anterior mandible dentition issues. The patients were divided into groups as follows: Group 1 — patients (n=12, 14.5%) who had undergone orthopedic treatment with no dental implants used; Group 2 — patients (n=25, 30.0%) who had dental implants installed 5–6 following the teeth removal (comparison group), while the load on the installed implants was applied 3–6 months later (Fig. 1);

Impro, AnyRidge, AnyOne, Osstem MS; diameter — 2.5–3.3 mm; length — 10 mm) were installed in the frontal mandible.

To identify the stability and osseointegration, a MEGA ISQ device was used, the performance of that based on the registration of resonant electromagnetic vibrations of the implant and of the surrounding bone. MEGA IQ identifies the implant stabilization via calculating the difference in the resonant frequencies between the test pin screwed onto the implant and the analyzing unit. The magnet on the pin is exposed to electromagnetic impulses, with the vibrations further evaluated on a 0 to 100 scale. A value exceeding 70 units points at a high primary stabilization of the implant. Radiofrequency analysis can help quantify the stabilization of the implant as well as its changes over time, such as the force of fixation of the implant in the bone.

Fig. 1. *Two-stage dentition defect implantation in the anterior mandible with delayed loading (a-h)*

Group 3 — patients (n=28, 34.0%) who had dental implant installed straight into the replaced tooth's hole with immediate load applied on the implants, whereas they were administered medication treatment following the surgery (with no Imudon® lozenge administered); Group 4 — patients (n=18, 21.5%) who had undergone an implantation surgery with the implant installed right into the hole of the removed tooth, with immediate load on the implants and further administration of Imudon® lozenges within the post-surgery period (daily dosage — 6 lozenges; course duration — 10 days) (Fig. 2).

The cone-beam computed tomograms (CBCT) of the 83 patients with dentition issues were performed on a PointNix Combi 500 computer tomography device. 110 implants of various systems (Alpha BIO,

The object of the immunological study was the crevicular fluid. The cytokine content was examined 7 days and 1 month following the implants installation. The substances identified in the vascular fluid by solid-phase enzyme immunoassay (using Vector Best reagent kits; Novosibirsk, Russia) were interleukin-8 (IL-8), interleukin-1 receptor antagonist (IL-1RA), monocytic chemoattractant protein (MCP-1), tumor necrosis factor alpha (TNFα). The effectiveness of the reparation and osseointegration was done through the repair index:

(RI). RI = IL-1RA / (IL-8+MCP-1+TNFα).

The statistical processing of the data was performed using the Statistica 6.0 software for Windows.
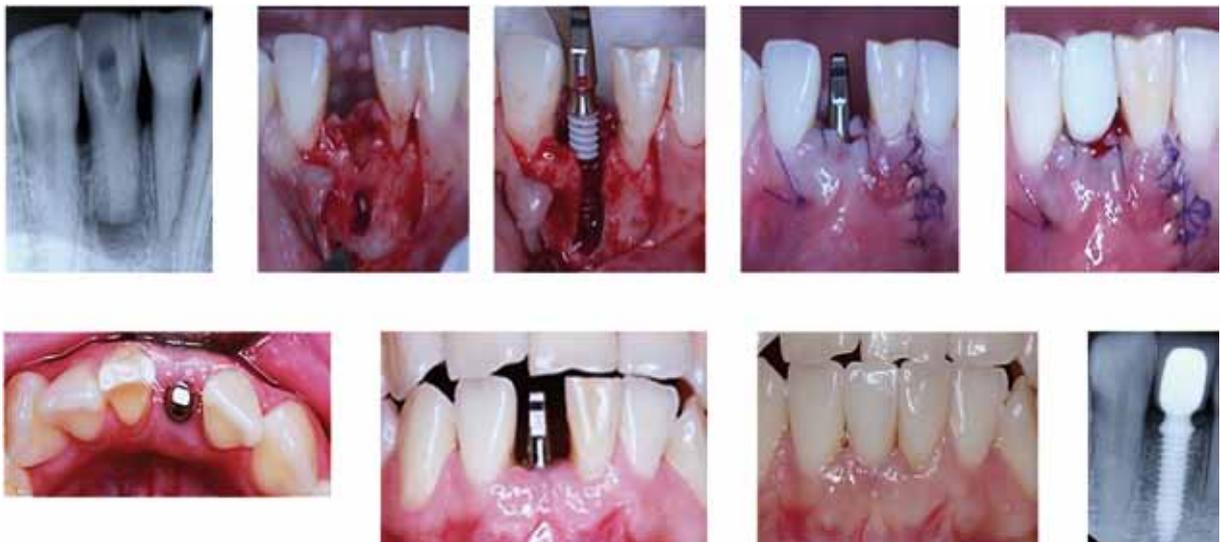
Fig. 2. One-stage implantation and direct prosthetics of a dentition defect in the frontal mandible (a-i)

RESULTS AND DISCUSSION

Prior to the surgery, each patient was offered full information regarding the upcoming intervention, treatment plan, expected results and associated risks. The preoperative examination included a thorough collection of a personal medical history, as well as clinical and radiological data. The quality and the quantity of the alveolar bone tissue in the anterior mandible were evaluated, too. As the CBCT data shows, the 1st type of bone tissue with a compact layer predominating was found in 10.1% of the cases (n=9); the 2nd type of bone tissue — a combination of a spongy and compact layer (1:1 ratio) was to be observed in 35.5% of the cases (n=29), the 3rd type of bone tissue — the spongy layer predominating, with a typical network of thin trabeculae, was found in 47% of the cases (n=39), while the 4th type of bone tissue, featuring a 4:1 spongy VS. compact layer ratio, was detected in 7.4% of the cases (n= 6) (Fig. 3).

The height of the anterior mandible measured from the ridge top to the lower edge of the mandible in 77 (93%) patients was 15 mm or above. Anatomical and topographic measurements were carried out at a point located on the vertex of the alveolar ridge and every 5 mm to the lower edge of the jaw. When examining the area of the 42nd tooth (removed previously), the average width at the first point (the alveolar ridge tip) was 2.2 ± 0.01 mm; at the second — 3.8± 0.01 m; at the third — 4.9 ± 0.01 mm, and at the fourth — 5 ± 0.02 mm. The area of the 41st previously removed tooth could be described as follows: at the first point — 2.2± 0.01 mm; at the second — 4.2±0.01mm; at the third — 5.6±0.02 mm, at the fourth — 6±0.02 mm. The area of the 31st previously extracted tooth: at the first point — 2.2± 0.01 mm; at the second point — 4.2± 0.01 mm; at the third point — 5.9± 0.01 mm; at the fourth — 5.6±0.02 mm. The area of the 32nd previously removed tooth: at the first point — 1.6± 0.01 mm; at the second — 3.1±0.01 mm; at the third — 4.4± 0.01 mm, and at the fourth — 6.1±0.02 mm. surgical treatment was initiated once the structure of the bone tissue was studied completely.
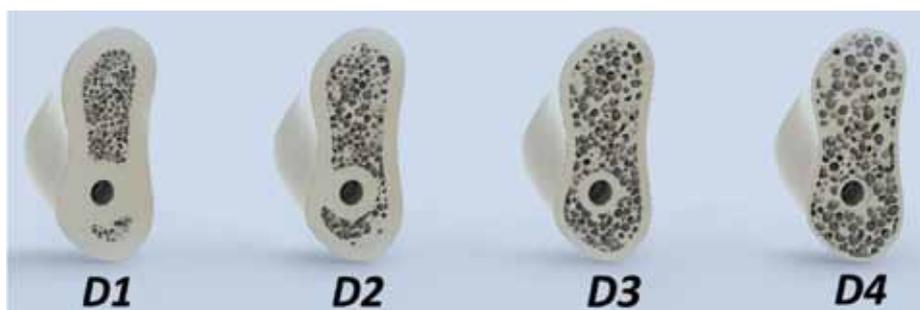

Fig. 3. Bone density classification (C.E. Misch, 1990)

When installing an implant in the respective hole, ensuring high primary stability of the implant is of importance. There was a dependence identified between the bone tissue density and the primary stability indicator. The stability figures for implants installed in Type 1 bone tissue fell within the range of 78 to 90 units, for implants installed in Type 2 bone tissue — from 76 to 90 units.

The primary stability values for implants embedded in Type 3 bone tissue were much lower, ranging from 65 to 70 units. As for as Type 4 bone tissue is concerned, the primary stability of the implanted implants was under 60 units. Out of all the implants loaded directly on the day the surgery was done, 12 (32.4%) implants were installed in Type 1 bone tissue (primary stability on the MEGA ISQ device ranging from 88 to 90 units); 20 (54.1%) implants were installed in Type 2 bone tissue (primary stability — 85–88 units) and 5 (13.5%) implants in Type 3 bone tissue (primary stability — from 78 to 79 units). The next examination of the stability featured by the implants with immediate loading was carried out 1 month after surgical treatment. At this point, the plan was to replace the temporary orthopedic structure with a permanent one. A measurement of the stability of the implant (MEGA ISQ device) installed in the bone tissue of Type 1 and 2, which was done 1 month following the surgery, revealed no decrease in the stability values. One of the 5 implants installed in Type 3 bone tissue and loaded on the day of surgery showed a stability decrease down to 65 units.

Once the implant is installed, the top important task is to identify and early postoperative complications. During the first 7 days, and a month following delayed installation of implants, and immediate installation of implants right into the hole of the extracted tooth, there is a change in the content of pro- and anti-inflammatory cytokines in the crevicular fluid. Inflammation at the lesion comes along with predominating activity of pro-inflammatory interleukins-IL-8, MCP-1, TNFα synthesis. In the postoperative period, on Day 7 and a month following the installation of the implants, patients who underwent delayed implantation, as well as those who underwent immediate implantation, had the level of IL-1RA at 35–36.7% of the level of Group 1 (p<0.001) and 33.6–36.9% (p<0.001). The TNFα content was 88.2% on the 7th day and 78.9% – a month later, from the level of Group 1 indicators 1 (p<0.01), in patients who underwent delayed implantation, and in patients who underwent immediate implantation — 73.7% of Group 1 indicators (p<0.01). The content of IL-8 in the gingival fluid on Day 7 day and a month following the installation of implants in patients who underwent delayed implanta-

tion went down to 23.4% and 23.0–32.9% of Group 1 levels (p<0.01); in Group 3 after immediate implantation — 23.7% and 14.8–26.5% of Group 1 levels (p<0.01). In the postoperative period, on Day 7 and a month later, only the MSR-1 content was growing. The content of MCP-1 in the gingival fluid, during that, was observed to be increasing only in patients who had undergone delayed implantation — up to 113.5–121.2% of Group 1 levels (p<0.05); in those who had had immediate implantation, it fell to 77.8% of Group 1 levels (p<0.01) (Table 1).

A local imbalance in cytokine production, therefore, accounts for the development of chronic inflammation, which requires immune medication treatment that will affect the cytokine status. We found that against the background of treatment with Imudon®, there were changes in the balance of pro- and anti-inflammatory cytokines typical of the two groups of patients described above (with delayed and with immediate installation of implants). In the postoperative period, the decrease in the IL-1RA levels on day 7 was up to 73.8% (p<0.05), whereas following one month its content recovered almost to Group 1 levels. The decrease in pro- and anti-inflammatory cytokines in the postoperative period in patients taking the Imudon® occurred was going on not so significantly, i.e. a mechanism was triggered, which promoted bone regeneration.

For evaluating the effectiveness of reparation and osseointegration, as well as possible complications of dental implantation in the early postoperative period, there was the ratio index calculated for pro- and anti-inflammatory cytokines. The RI calculation showed that in the postoperative period, patients in groups with delayed and immediate implantation had the indicator — on Day7 and a month later — went down to 24.7 and 26.8 units, and to 29 and 31.2 units (p<0.05). The decrease in RI in these groups of patients points at a high activity of the postoperative inflammation, which is accompanied by the development of pain syndrome, and a postoperative edema followed with loss of bone tissue around the implant. Decreasing pro- and pro-inflammatory cytokine pools in the postoperative period in patients taking Imudon® was less pronounced, which means that after immediate implantation into the extracted tooth's hole, the mechanism was triggered, which was responsible for cytokine regulation of processes promoting bone tissue reparative regeneration. A typical feature of this was a significant increase in RI — 110.50 units after 7 days, and 134.95 units — after a month (p<0.01).

CONCLUSIONS

1. As cone-beam computed tomography data shows, identifying the stability and osseointegration,

Table 1. The cytokine level in the gingival fluid after the installation of dental implants in the early postoperative period (mean value and quartile range)

Study groups	MCP-1 (pg / ml)	IL-1RA (pg / ml)	IL-8 (pg / ml)	TNF α (pg / ml)	RI (units)
Group 1 (Control group)	28,9 (26,6;32,1)	4279,50 (3655,0;4951,0)	69,50 (13,85;96,02)	7,60 (5,87;9,50)	42,60 (36,55;53,51)
Group 2 (Comparison group)					
7 days later	32,80 (29,35;45,20)	1498,00 (1367,00;1836,00)	16,20 (13,70;17,80)	6,7 (5,50;8,45)	24,70 (22,45;30,90)
30 days later	32,75 (28,68;37,33)	1568,50 (1454,25;1604,00)	16,00 (13,30;16,50)	6,70 (5,90;7,00)	26,80 (23,70;28,34)
Group 3 (Immediate implantation)					
7 days later	22,30 (15,25;30,73)	1437,30 (1314,08;1518,23)	16,05 (13,75;20,53)	5,60 (5,30;6,30)	29,55 (25,40;31,90)
30 days later	28,9 (26,65;32,15)	1498,00 (1367,00;1836,00)	10,30 (9,75;23,55)	4,60 (4,20;4,75)	31,20 (29,30;40,70)
Group 4 (Immediate implantation + Imudon®)					
7 days later	4,89 (3,45; 8,26)	3160,00 (2995,00;3860,00)	32,27 (17,80;46,80)	2,12 (1,83;2,85)	110,50 (88,47;116,60)
30 days later	6,46 (4,45; 8,04)	4570,00 (3733,00;4800,00)	19,50 (11,80;44,70)	2,07 (1,63;2,75)	134,95 (78,90;215,01)

restoring anterior mandible dentition defects can be done during dental implantation performed subject to the delayed and immediate installation protocol.

2. Direct prosthetics on implants with immediate functional load offers a good alternative to the standard treatment protocol, also featuring the following advantages: a low degree of surgical intervention; a short treatment period; the capacity to maintain the height and width of the alveolar bone at a stable level; accelerated bone regeneration. Reduced treatment course down to one month is possible in case of the right selection of patients who feature good quality of bone tissue, mucous membrane, as well as the right height and width of the alveolar process.

3. The bone tissue structure and density, with Type 1, 2 and 3 of bone tissue, allows primary stability of implants in the anterior mandible that is enough to carry out immediate loading involving removable and/or non-removable dentures.

4. The implant stability of 75 units and above (as measured on a MEGA ICQ device) allows predicting a guaranteed stable outcome with immediate loading applied to dental implants.

5. The administration of the Imudon® drug in the postoperative period is an effective treatment and prevention measure that can be employed for the rehabilitation of patients after dental implantation, the measure in question reducing the risk of inflammation-induced complications.

6. One of the advantages to be gained through immediate implantation is nearly complete absence of atrophic changes at the surgery area, while it requires atraumatic tooth extraction along with preserving all the bone walls of the hole; in case any defects occur, the method of directed bone and tissue regeneration should be employed. Achieving primary stability of the implant installed in the hole of the extracted tooth will take its maximum contact with the bone walls in the hole as well as possible further early loading.

7. In case of one-stage implantation and direct prosthetics, implants should be installed inside the holes of teeth that have no an acute or chronic inflammation, while this method should be used carefully in cases featuring periodontal issues. When an implant is installed immediately into a single-root tooth's hole, it would be reasonable to ensure maximum match between the implant shape and the dental alveolus anatomical shape.

REFERENCES

1. Dolgushin I.I., Latyushina L., Piotrovich A.V., Nikushkina K.V. Effect of local immunocorrection on saliva cytokine profile during the "closed" sinus lifting and simultaneous implantation // Cytokines and inflammation. 2016;2:198–203. http://www.cytokines.ru/russian/2016/2/Art12.php.

2. Erokina N. L., Lepilin A. V., Zakharova N. B. Profile of cytokines in the content of periodontal pockets in patients with fractures of the mandible with periodontitis. Clin.lab. diagnostics 2011;9:6–7.

3. Lepilin A.V., Smirnov D.A., Mostovaya O.S., Zhilkina O.V. Questioning results of dental clinic patients on the use of the dental implantation method.

Scientific and practical journal "Dentistry". MediaSfera, 2013;3;Vol.92:112–113.

4. **Lepilin A.V., Erokina N.L., Savelyeva S.S., Ageev A.B.** Features of the use of domestic dental implants. Dental Forum, 2016;4:50.

5. **Lepilin A.V., Shalina M. Yu., Halturina V. G., Martynova M. I.** the Use of cone-beam computed tomography to study the anatomical and topographic structure of the alveolar part of the chin of the lower jaw. Dental Forum, 2017;4(67):47–48. https://elibrary.ru/item.asp?id=30504296.

6. **Lepilin A.V., Shalina M.Y., Savel'eva S.S., Mukhina N.M., Nozdrachev V.G.** Predicting the possibility of immediate dental implants loading by frequency-resonance analysis. Clinical Dentistry, 2018;2(86):50–53.

7. **Lepilin A. V., Zakharova N. B., Fishchev S. B., Shalin M. Y.** Peculiarities of the dynamics of the cytokine profile of angiogenesis in the gingival fluid of patients with the installation of dental implants. Periodontology, 2018; 1:26–29. DOI: 10.25636/PMP.1.2018.1.6.

8. **Lepilin A. V., Ostrovskaya L. Yu., Zakharova N. B., Erokina N. L.** Modern technologies and substantiation of pathogenetic treatment of periodontal diseases. – Saratov: Publ., SGMU, 2015. – 138p.

9. **Lepilin A.V., Mostovaya O.S., Konnov V. V., Maslennikov D. N.** Directly installation of a dental implant in the hole of a removed tooth // Dental implantology and surgery. 2015. №4 (21). P. 36–38. https://elibrary.ru/item.asp?id=29299839

10. **Lepilin A.V., Raygorodsky Yu.M., Erokina N.L., Smirnov D.A., Listopadov M.A.** Rationale for the use of physiotherapy after dental implantation. Periodontology, 2010; Vol.15;2(55):62–64.

11. **Lepilin A.V., Raygorodsky Yu.M., Erokina N.L., Bulkin V.A., Prokofieva O.V., Smirnov D.A.** Application of physiotherapeutic techniques for the improvement of the efficacy of dental implantation. Questions of balneology, physiotherapy and physiotherapy, 2010;4: 15–16. https://elibrary.ru/item.asp?id=15271445.

12. **Lepilin A.V., Erokina N.L., Titorenko V.A., Ostrovskaya L.Yu., Bisultanov H.U.** The condition of periodontal tissues in patients with mandibular fractures in combination with inflammatory diseases of periodontium in dynamics of treatment. Saratov Journal of Medical Scientific Research, 2008; Vol. 4;1: 115–118.

13. **Rabinovich I. M., Rabinovich O. F.** Experience of clinical use of Imudon in the treatment of diseases of the oral mucosa. Clinical dentistry. 2000; 66(3): 64–65.

14. **Tsepov L.M., Orekhova L.Yu., Nikolaev A.I., Mikheeva E.A.** Certain aspects of etiology and pathogenesis of chronic inflammatory periodontal diseases (review). Chapter I. Periodontology, 2005; 2 (35): 3–6.

15. **A. Dasanayake.** Periodontal disease is related to local and systemic mediators of inflammation. J Evid Based Dent Pract. 2010;10(4):246–247. https://doi.org/10.1016/j.jebdp.2010.09.006.

16. **T. R. Fitzsimmons, A. E. Sanders, P. M. Bartold, G. D. Slade.** Local and systemic biomarkers in gingival crevicular fluid increase odds of periodontitis, J Clin Periodontol. 2010;37(1):30–36. https://doi.org/10.1111/j.1600-051X.2009.01506.x.

17. **M. L. Geisinger, B. S. Michalowicz, W. Hou, E. Schoenfeld, M. Gelato, S. P. Engebretson, L. Hyman.** Systemic inflammatory biomarkers and their association with periodontal and diabetes-related factors in the diabetes and periodontal therapy trial, a randomized controlled trial. Journal of Periodontology. 2016;87(8):900–913. https://doi.org/10.1902/jop.2016.150727.

18. **T. Shimizu, T. Kubota, M. Iwasaki, T. Morozumi.** Changes in Biomarkers after Initial Periodontal Treatment in Gingival Crevicular Fluid from Patients with Chronic Periodontitis Presenting with Drug-Induced Gingival Overgrowth. Open Journal of Stomatology. 2016;6(2):64–72. http://dx.doi. org/10.4236/ojst.2016.62008.

19. **S. Ramalingam, M. Al-Hindi, R. A. Al-Eid, N. Nooh.** Clinical evaluation of implant survival based on size and site of placement: A retrospective study of immediate implants at single rooted teeth sites. The Saudi Dental Journal. 2015; Vol. 27; 2:105–111. DOI: 10.1016 / j.sdentj.2014.11.003

20. **Bairikov I.M., Gaivoronskaya T.V., Dedikov D.** Reconstruction of mandibular defects using individual vascularized autografts combined with macroporous titanium fiber material // Archiv EuroMedica. 2021. Vol. 11. № 1. P. 147–159. https://doi.org/10.35630/2199-885X/2021/11/1.32

21. **Kupryakhin S.V., Lepilin A.V., Kupryakhin V.A.** Optimization of dental implantation combined with closed sinus lift in patients with low maxillary sinus floor // Archiv EuroMedica. 2019. Vol. 9; 2: 117–121. https://doi.org/10.35630/2199-885X/2019/9/2/117

22. **Kupryakhin S.V., Lepilin A.V., Kupryakhin V.A., Postnikov M.A.** Potential introduction of cell technologies to improve dental implant surface preparing // Archiv EuroMedica. 2019. Vol. 9; 2: 122–129. https://doi.org/10.35630/2199-885X/2019/9/2/122