

# The influence of immediate intraoperative loading with a splinting component on supporting tissues during a one-stage implant

Anatoliy Potapchuk<sup>1</sup>, Vasyl Almashi<sup>1</sup>, Yevhen Onipko<sup>1</sup>, Csaba Hegedűs<sup>2</sup>

<sup>1</sup>UZHGOROD NATIONAL UNIVERSITY, UZHGOROD, UKRAINE

<sup>2</sup>UNIVERSITY OF DEBRECEN, DEBRECEN, HUNGARY

## ABSTRACT


**Aim:** To study the specifics of the impact of immediate intraoperative loading with a splinting component on supporting tissues during a one-stage implantation protocol.

**Materials and Methods:** In the course of the study, orthopedic treatment was carried out for 55 patients aged 29 to 60 years. The following were performed: cone-beam computed tomography, software planning and intraoral scanning with an optical scanner, one-stage implantation protocol, assessment of implant stability with the Osstell ISQ device, microcirculation study in the peri-implant area using laser Doppler flowmetry (LDF).

**Results:** It was established that around loaded implants there is an increase in blood flow and vasomotor activity of the microcirculatory channel of the supporting tissues, an increase in the volume of bone tissue and an increase in torque, which is the optimal forecast for the acceleration of the pace of osseointegration.

**Conclusions:** The use of a splinting component during immediate intraoperative functional masticatory load accelerates the dynamics of bone tissue remodeling processes around the implant, which is an optimal prediction of osseointegration rates in various dental implantation protocols and is consistent with high values of the implant stability coefficient.

**KEY WORDS:** one-stage dental implantation protocol, immediate intraoperative load, splinting component, LDF (laser Doppler flowmetry), stability indicator

Wiad Lek. 2024;77(3):462-471. doi: 10.36740/WLek202403114 

## INTRODUCTION

Based on the results of monitoring and analysis of clinical and experimental studies on the success of dental implantation in the early and long-term follow-up periods, scientists were able to justify the feasibility of introducing into clinical practice not only classical, but also modified implantation protocols with different periods of follow-up load [1,2]. The systematization of modern views on the differentiation of the results of immediate loading and immediate implantation and their interpretation from the point of view of the modern understanding of the mechanisms of bone remodeling expands the opportunities for discussion and argumentation of the prognosis of various dental implantation protocols, taking into account the initial conditions of the clinical situation [3-6]. As the analysis of scientific sources on dental implantation shows, specialists are increasingly turning to one-stage implantation with the use of immediate loading [5, 7-9]. Today, there are discussions about the features of the formation and the level of reduction

of peri-implant bone tissue in various conditions, in particular, under load and micromobility [10].

Specialists in practical dentistry do not have a single opinion regarding the terms of application of immediate masticatory load. Most of the publications are devoted to determining the indications and evaluating the clinical results of prosthetics before the use of immediate loading, diagnostics and anatomical and topographical features of bone tissue in the areas of implant installation with complete and partial adentia [11-13]. The influence of personalized dental implantation protocols on the processes of osseointegration and analysis of the results is also being studied prosthetics with the use of immediate loading [14-16]. The very term immediate load also causes controversy among clinicians. Foreign researchers define a period of up to 48 - 72 hours between the implantation operation and the installation of a temporary prosthesis, as the period of the beginning of the impact of immediate load on the implants [17].

In clinical practice today, there is a tendency to shorten the terms of predicted and successful orthopedic rehabilitation. Dental implantation with immediate intraoperative functional chewing load allows to reduce the duration of treatment and the volume of surgical intervention and to obtain a high functional and aesthetic result. Such a modified surgical protocol can be performed only by specialists with high manual capabilities and extensive clinical experience, if certain clinical conditions are met and maintained [16-18].

In this regard, especially in recent years, the commitment of patients and dental specialists to the use of immediate masticatory loading with implant-supported dentures in the treatment of patients with partial and complete edentation of the jaws has significantly increased. The capabilities of computer tomography (CT) and computer programs (3d modeling), which are used in the planning of dental implant technologies and dental prosthesis designs, have expanded [18-20].

The success of treatment is usually associated with individual protocols, which include the use of temporary splinting prostheses at almost all clinical stages, starting from the moment of installation of implants and covering the period of their osseointegration, up to the manufacture of permanent dental prostheses [19,21,22].

To date, precise objective hardware assessment of osseointegration is not possible. The stability of implants can be interpreted as the absence of their clinical mobility, which is also one of the criteria for osseointegration. Therefore, achieving and maintaining the stability of implants is the main condition for a successful long-term clinical result of implantation [22, 23].

Nevertheless, clinically stable implants also have micromobility when they are loaded. When a lateral load is applied to an osseointegrated implant, the implant is displaced, but returns to its original position immediately after its removal, depending on the type of peri-implant bone. A stable implant may have varying degrees of stability (ie, varying degrees of displacement or resistance to loading) depending on factors related to bone quality, surgical technique, and implant design. Therefore, the result of the assessment of implant stability largely depends on the assessment method. It has been established that around loaded implants there is an increase in blood flow and vasomotor activity of the microcirculatory bed of the supporting tissues, an increase in the volume of bone tissue and an increase in torque, which is an optimal prediction of the acceleration of the rate of osseointegration [23].



**Fig. 1.** Clinical situation before the operation.

In modern implantology, standard examination methods do not allow detecting disorders that occur in the peri-implant mucosal zone during dental implantation. Therefore, the use of highly informative methods of assessing hemodynamics and metabolism reveals hidden mechanisms of disease development. To date, the most objective method of assessing the state of microcirculation is laser diagnostics, in particular laser Doppler flowmetry [24, 25], the use of such a technique allows for the analysis of capillary hemodynamics on a real-time scale and allows to determine changes in microcirculation during various protocols of dental implantation and functional load [26-28].

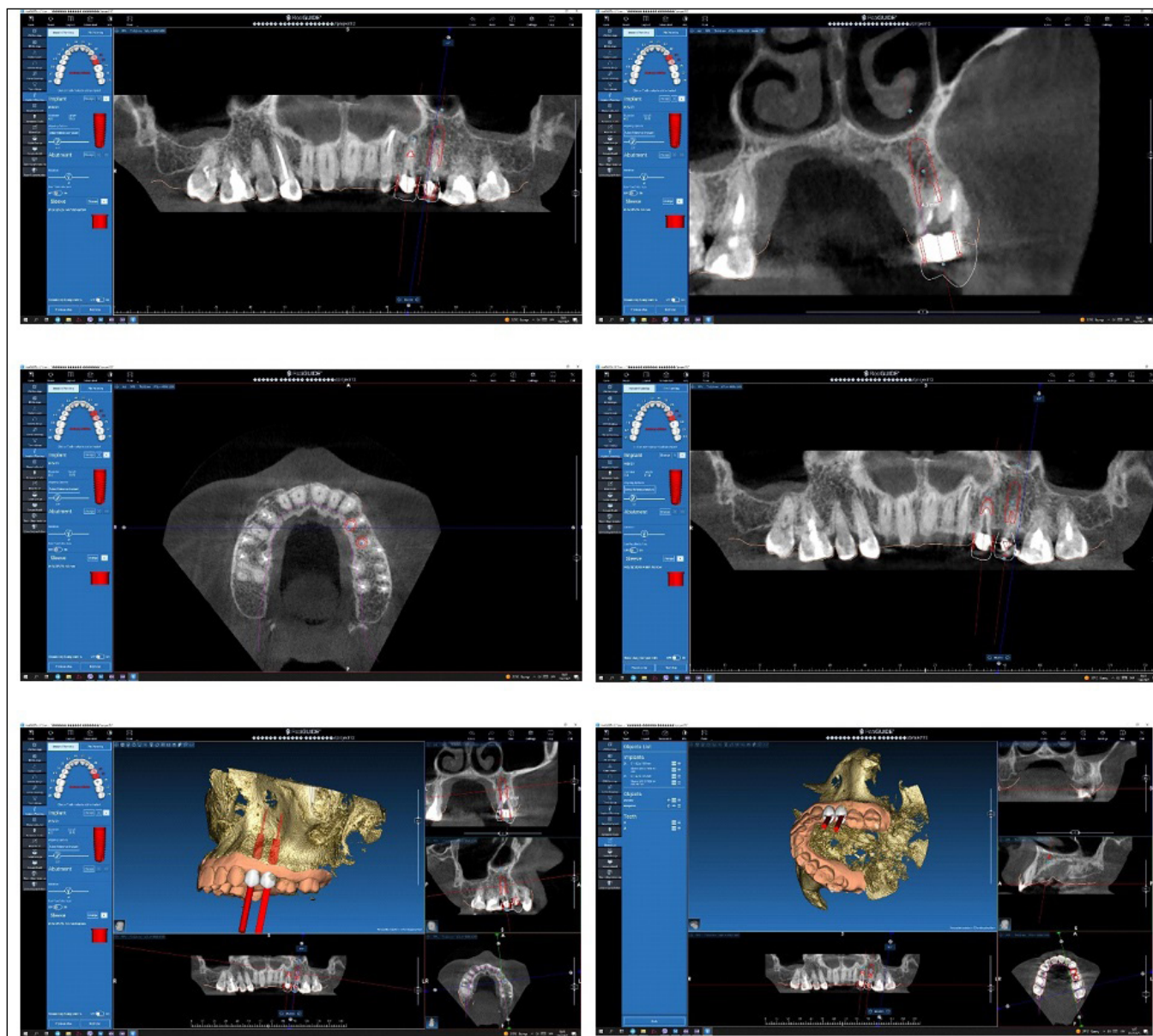
## AIM

To study the specifics of the impact of immediate intraoperative loading with a splinting component on supporting tissues during a one-stage implantation protocol.

## MATERIALS AND METHODS

The clinical study was conducted on the basis of the Department of Post-Graduate Education Dentistry of the Uzhhorod National University, the dental clinic «Art dentistry» (Zaporizhia, Ukraine), the university dental clinic of Debrecen University (Debrecen, Hungary) in the period 2020-2024.. The study was carried out taking into account the main provisions of the GCP ICH and the Helsinki Declaration on Biomedical Research, the Council of Europe Convention on Human Rights and Biomedicine (2007) and the recommendations of the Committee on Bioethics under the Presidium of the National Academy of Sciences of Ukraine (2002) and the positive opinion of the bioethics commission of the Uzhhorod National University .

Orthopedic treatment of 55 patients aged 29 to 60 years was performed according to the proposed



**Fig. 2.** Cone-beam computed tomography (three-dimensional model of the upper jaw) with virtual simulation of dental implant installation.

treatment protocol. All patients were fitted with dental implants in the defect area of 1-2 teeth on the upper jaw with immediate loading, using intraoperative prosthetics. A total of 65 implants of the ART IMPLANT system were installed (certificate of compliance of products with requirements NoUA.101.MD.3.1024 - 23.00).

Planning and treatment of patients was carried out according to the following algorithm: cone beam computed tomography (CBT) was performed to obtain files in dicom format for further planning of dental implant installation. Later, after intraoral scanning with an optical scanner to obtain a file in STL format, dicom and STL format files were combined in the 3Diagnosis computer program to display the complete clinical picture, which includes all anatomical formations of

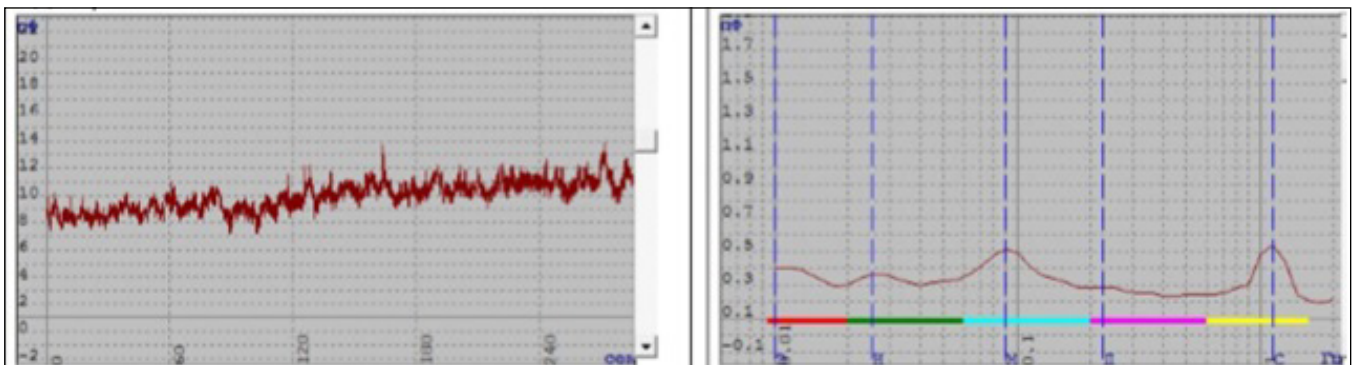
the selected area, virtual positioning of the implant and its superstructure was carried out. A virtual model of the surgical template was created using the received data on the state of the implant in the PlastyCAD software. The template was printed using a 3D printer. Milled provisional splinting structures were made beforehand, followed by their rebasing in the oral cavity on temporary titanium abutments fixed to the Multi-unit abutment. Under the condition of using Basis implants of the Art Implant system, temporary splinting structures were made in advance according to the Malevez Chantal method. A feature of the ART IMPLANT system implant thread is a trapezoidal compression shape, which turns into a cutting shape - this, in turn, contributes to the condensation of the cancellous bone and ensures reliable primary



**Fig. 3.** Clinical situation after one-stage surgical implantation protocol after 14 days.



**Fig. 4.** Clinical situation after one-stage surgical implantation protocol after 3 months.



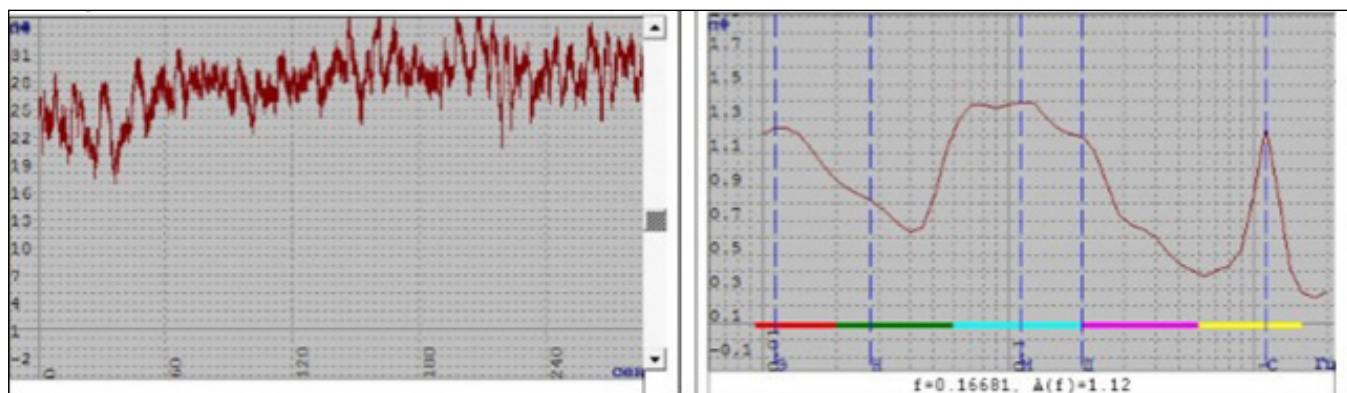
**Fig. 5.** Indicators of microcirculation according to LDF data in patient A. before dental implantation surgery.

stability, while not losing the self-tapping properties of the implant, which greatly facilitates its installation.

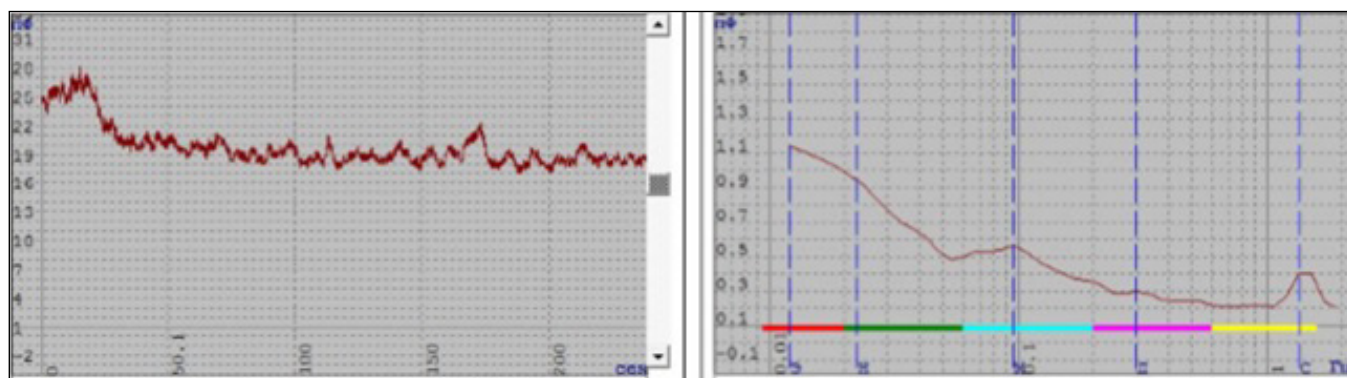
The stability of the implant was assessed by the value of the stability coefficient using the Osstell ISQ device (Integration Diagnostics, Sweden). Also, the patients underwent a study of microcirculation in the peri-implant zone by laser Doppler flowmetry (LDF) using the moor VMS LDF2 system (( $785 \pm 10$ ) nm, maximum power 2.5 mW) (Moor Instruments Ltd. Millwey Axminster Devon EX13 5HU, Great Britain ) and

processed using specialized software (moor VMS-PC, V 3.1 for Vascular Monitor System).

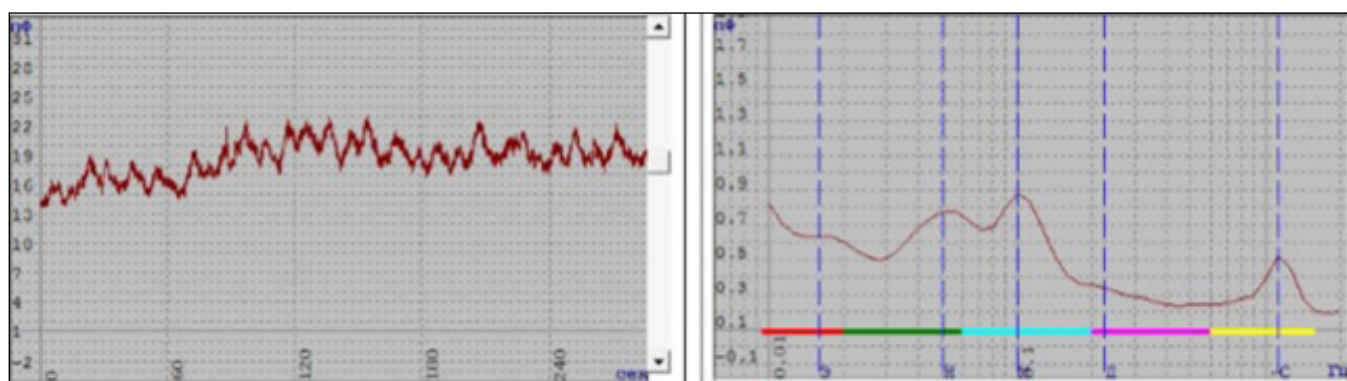
The results of laboratory and clinical studies were processed by methods of variational statistics with determination of the mean value, its errors, Student's t-test for multiple comparisons, using Excel (MS Office 2018, Microsoft, USA) and STATISTICA 6.0 (StatSoft, USA). Differences in indicators at the level of significance  $p < 0.05$  were considered statistically significant.



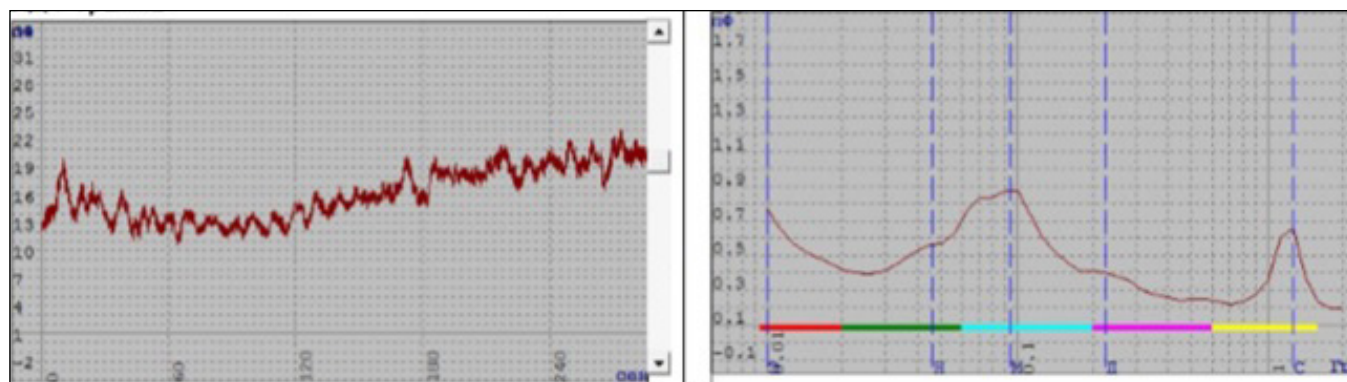
**Fig. 6.** Indicators of microcirculation according to LDF data in patient A. 3 days after dental implant surgery and immediate intraoperative prosthetics.



**Fig. 7.** Indicators of microcirculation according to LDF data in patient A. 10 days after dental implant surgery and immediate intraoperative prosthetics.



**Fig. 8.** Indicators of microcirculation according to LDF data in patient A. 1 month after dental implant surgery and immediate intraoperative prosthetics.



**Fig. 9.** Microcirculation indicators according to LDF data in patient A. 3 months after dental implant surgery and immediate intraoperative prosthetics.

## RESULTS

When examining the dental status, attention was paid to patients' complaints, which were reduced to aesthetic and masticatory insufficiency caused by the presence of defects in the dentition, difficulties in chewing food on the side of the defect. The examination includes an assessment of the state of the periodontal teeth, detection of dentition deformations and determination of the level of oral hygiene. Analysis of patient history data showed that the cause of tooth loss in all patients was a complication of caries.

On the diagnostic models of the jaws, the relationship of the tooth rows during various occlusal movements was studied, some anthropometric parameters were determined - the length of the tooth row defect, the width and height of the edentulous alveolar ridge. In the articulator, with the help of diagnostic models, the structural features of the future dental prostheses were specified, and the relationship of the implant head with the opposing teeth was also determined. Kennedy's classification was used to systematize dentition defects and determine the indications for choosing the type of implantation and the design of a dental prosthesis: 61% of patients were missing one tooth, 39% were missing two teeth. Depending on the type of dentition defect, all patients underwent orthopedic treatment with the manufacture of fixed structures supported by dental implants.

## CLINICAL CASE

Patient A., born in 1962, diagnosed with chronic irreversible periodontitis of teeth 2.4, 2.5 (Fig. 1).

A clinical and radiological examination was carried out using cone-beam tomography and computer virtual simulation of the stages of surgical and orthopedic treatment. We also determined the condition and dimensions of the implant, measured the distance to the maxillary sinus, the volume of bone tissue of the alveolar process of the upper jaw in the projection of teeth 2.4, 2.5 (Fig. 2).

After the examination, the patient's treatment plan was drawn up: a one-stage surgical protocol of implantation with Basis dental implants of the ART IMPLANT system with bone plastic and one-moment intraoperative provisional prosthetics with splinting component was carried out (Fig. 3).

Three months after the operation, a permanent metal-ceramic bridge-like prosthesis was made (Fig. 4).

After 1 year, the patient has no complaints, a satisfactory state of oral hygiene is noted, the mucous membrane is pale pink in color, moderately moisturized, without signs of gingivitis. The installed crown

is stable, without clinical and radiological signs of peri-implantitis, slight recession of the gingival margin is noted.

The study of the microcirculation of the mucous membrane in the peri-implant zone by the method of laser Doppler flowmetry (LDF) was carried out before the operation, as well as 3 days, 10 days, 1 month and 3 months after implantation (Fig. 5, Fig. 6, Fig. 7, Fig. 8, Fig. 9).

The results of LDF-gram wavelet analysis, shown in Table 1, revealed an increase in the neurogenic tone (NT) of precapillary vessels in the microcirculatory channel of the mucous membrane of the jaws 3 days after dental implantation with immediate loading by 14.77% ( $p < 0.05$ ), and after 10 days - a decrease by 28.11% ( $p < 0.001$ ) compared to the initial values.

After 1 month (Table 2) after the operation, NT tended to increase, but its values were lower than the initial level by 17.78% ( $p < 0.05$ ). After 3 months, NT exceeded the initial level by 30.05% ( $p < 0.05$ ). The index of myogenic tone (MT) after dental implantation with immediate loading after 3 days tended to decrease, and after 10 days after the operation, its value increased by 96.86% ( $p < 0.001$ ).

1 month after dental implantation with immediate loading, MP values dropped and differed from the preoperative level by 11.07%, and by 21.98% after 3 months ( $p < 0.05$ ).

The value of the shunt index (SI) 3 days after dental implantation had a tendency to decrease, and after 10 days its values increased by 3.11 times, which may indicate the reaction of the microcirculation in the mucous membrane to the traumatic injury of the jawbone during dental implantation and immediate intraoperative prosthetics ( $p < 0.001$ ). 1 month after the operation, the SI decreased and was higher than the initial level by 38.02% ( $p < 0.05$ ), and after 3 months, its values slightly differed from the preoperative level.

When assessing the stability of dental implants using the «Osstell ISQ» device (Sweden), a clinical and functional examination of the state of supporting tissues in the area of the implant on the upper jaw was carried out in 55 patients with a diagnosis of partial absence of teeth (ICD-10 - 08.1), the size of the defect - one - two teeth.

The installed implants reached an average level of stability, in particular for implants of the ART IMPLANT system - the stability coefficient was from 65 to 75 (percentage point), which on average is  $(71 \pm 0.5)$  percentile. These data indicate that the stability of the implant allows planning the beginning of prosthetics with permanent orthopedic structures (Table 3).

**Table 1.** State of the basic parameters of the microcirculation of the peri-implant zone of the upper jaw during dental implantation with immediate intraoperative prosthetics according to LDF data for the periods before the operation, after 3 and 10 days

Indexes	Before the operation			3 days after surgery			10 days after surgery			
	MI	$\sigma$	Kv	MI	$\sigma$	Kv	MI	$\sigma$	Kv	
n	25			23			23			
M $\pm$ m	8,50 $\pm$ 0,43	0,90 $\pm$ 0,04	10,59 $\pm$ 0,48	24,70 $\pm$ 1,24	2,80 $\pm$ 0,13	11,34 $\pm$ 0,52	19,20 $\pm$ 0,96	2,01 $\pm$ 0,09	10,47 $\pm$ 0,48	
p <				0,001	0,001				0,001	0,001

• MI - microcirculation index

• p is the reliability of the differences between indicators before the operation and in different periods after the operation.

**Table 2.** The state of basic indicators of microcirculation of the peri-implant zone of the upper jaw during dental implantation with immediate intraoperative prosthetics according to LDF data for the periods after surgery in 1 and 3 months

Indexes	1 month after surgery			3 month after surgery				
	MI	$\sigma$	Kv	MI	$\Sigma$	Kv		
n	21			19				
M $\pm$ m	16,90 $\pm$ 0,85	1,90 $\pm$ 0,09	11,24 $\pm$ 0,51	11,40 $\pm$ 0,57	2,10 $\pm$ 0,09	18,42 $\pm$ 0,84		
p <	0,001	0,001				0,05	0,001	0,001

• MI - microcirculation index

• p is the reliability of the differences between indicators before the operation and in different periods after the operation.

**Table 3.** Results of evaluation of the stability of ART IMPLANT implants according to the ISQ index (n=65)

Terms of observation	ISQ index (units)
At the time of installation of the implant	71,00 $\pm$ 0,10, p <0,05
14 days after implant placement	65,00 $\pm$ 0,08, p <0,05
1 month after implant placement	69,00 $\pm$ 0,03, p <0,05
3 months after implant placement	74,00 $\pm$ 0,05, p <0,05

Based on the results of frequency resonance analysis, it was established that implants with a high ISQ index (more than 65 u.o.) maintain an appropriate level of stability. However, due to the process of osseointegration, the primary mechanical stability is supplemented by biological stability.

The technology of frequency-resonance analysis provides the doctor with important information about the condition of the "implant-bone" connection area in the dynamics of treatment and control.

Studies have shown that implants with high stability coefficient values at follow-up examinations are successfully integrated, while low stability values may be a sign of implant failure.

## DISCUSSION

One of the most important conditions of dental implantology is the creation of conditions for long-term and stable stability of implants. The success of the introduction of non-biological implants into the bone depends on osseointegration, that is, the formation of a direct structural-functional connection between the implant and the bone. Data on the features of osseointegration, bone tissue state processes, bone formation

and resorption around dental implants with different optimized surfaces and its quality attract the attention of specialists in connection with the development of various installation and loading protocols (Zaid MB, O'Donnell RJ, Potter BK, Forsberg JA., 2019).

Fundamental studies of the condition of the bone tissue around the implanted material are important for evaluating the optimal timing of early functional loading of the implant, as early load function promotes osseointegration, however, in the complex context of bone remodeling, their disintegration is possible [11]. There is a study in which 29 articles corresponding to the inclusion criteria were selected out of 889, which is based on the evaluation of different loading protocols (immediate, immediate non-occlusal, early and conventional loading) of dental implants on the processes of osseointegration and marginal bone loss (Sommer M, Zimmermann J., Grize L, Stübinger S., 2020).

In the experiment, we performed a comparative analysis of the dynamics of remodeling of the bone tissue of the lower jaw of pigs under the conditions of using implants without splinting and with splinting components according to the indicators of the study of bone tissue formation at the interface "implant - bone" (bone implant contact, BIC) and distance (1000  $\mu$ m) (peri-implantation

area, BIV (bi i vi) to determine osseointegration and predict the long-term stability of implants. We observed that after 3 months after implantation, the BIC was 75%, statistically significantly higher compared to the use of implants without splinting - 47%, it was established, that in conditions without splinting for a period of 3 months after implantation, secondary remodeling occurs with increased osteoclastic resorption, which is a forecast of implant instability. To objectify the data of the morphological study, a morphometric comparative assessment of the integration of the implant with the bone in dynamics was carried out. It was proved that primary osteogenesis does not proceed according to the contact type, that is, starting from the surface of the implant, but according to the remote type from the side of the mother bone [11]. The obtained data are consistent with the research results of Adamantia Byraki, Anca Viochița Costea, George Cristian Curcă, Sorin Hostiuc (2019).

In a study by Barbier and colleagues (2011), in which immediate loading of implants installed immediately in sockets of extracted teeth and in sockets after healing was carried out, it was established that the time of implantation does not affect the level of reduction of peri-implant bone tissue ( $p > 0.3$ ).

The average decrease in the height of the bone crest relative to the reference reference point ranged from 0.25 mm to 0.48 mm after 1 year after loading the infrastructure, which corresponds to the scale of success criteria proposed by Albrektsson T. and Zarb G (1989). Considering the obtained indicators and the recorded 100% implant survival rate, the authors concluded that the proposed and described approach of immediate implantation with subsequent immediate loading can be considered successful, based on a 1-year monitoring period [12].

The data obtained by us allow us to conclude that when carrying out immediate loading during dental implantation according to our proposed method, the stability of the implant always remains sufficient for the

functioning of the implant.

Similar results were also described in the publication Chranovic B.R., Albrektsson T. and Wennerberg A. (2014), in which the authors noted that the cumulative rate of loss of intraosseous supports installed during the implementation of the immediate implantation protocol reached 4.0%, and exceeded the similar rate of implants, installed in the sockets of the teeth after their healing (3.09%) [12]. Thus, the researchers were able to establish that the relative risk of loss of dental implants, with immediate implantation, is 1.58 with a 95% confidence interval of 1.27-1.95 ( $p = 0.0001$ ). However, the difference between the survival of implants installed according to the immediate and delayed protocol was statistically justified only in cases of analysis of single orthopedic structures.

## CONCLUSIONS

The use of a splinting component during immediate intraoperative functional masticatory load accelerates the dynamics of bone tissue remodeling processes around the implant.

The use of laser Doppler flowmetry (LDF) is important for the analysis of capillary hemodynamics of the peri-implant zone, it allows to determine the dynamics of micro-circulation indicators, which is the optimal forecast of the rates of osseointegration in various protocols of dental implantation and functional load, which is consistent with high indicators of the coefficient of implant stability.

Thus, it should be stated that the clinical use of a one-stage surgical protocol of implantation with dental implants of the «ART IMPLANT» system in the rehabilitation of patients demonstrates a reliable degree of stability of installed dental implants and allows shortening the waiting period for permanent prosthetics, as well as reducing the duration of the entire treatment, which ultimately leads to increasing optimization of treatment efficiency and patient satisfaction.

## REFERENCES

1. Tonetti MS, Cortellini P, Graziani F et al. Immediate versus delayed implant placement after anterior single tooth extraction: the timing randomized controlled clinical trial. *J Clin Periodontol.* 2017;44(2):215-224. doi: 10.1111/jcpe.12666. [DOI](#)
2. Potapchuk AM, Rusyn VV, Onipko YeL et al. Porivnyal'nyy analiz rivniv reduktsiyi peryimplantatnoyi kistkovoyi tkanyiny pry realizatsiyi nehaynoho ta vidterminovanoho protokoliv dental'noyi implantatsiyi. [Comparative Analysis of Periimplant Bone Tissue Reduction Levels at Implementation of Dental and Immediatal Impalant Protocols]. *Novyny stomatolohiyi.* 2020;1:6-12. (Ukrainian)
3. Tarazona B, Tarazona-Álvarez P, Peñarrocha-Oltra D, Peñarrocha-Diago M. Relationship between indication for tooth extraction and outcome of immediate implants: A retrospective study with 5 years of follow-up. *J Clin Exp Dent.* 2014;6(4):384-388. doi: 10.4317/jced.51616. [DOI](#)
4. Potapchuk AM, Onipko YL, Almashi VM, Hegedús C. Comparative evaluation of clinical application of monolithic and folding implants in rehabilitation of elderly patients with various degrees of atrophy of alveolar processes. *Wiad Lek.* 2022;75(4(2)):921-8.
5. Montero J, Fernández-Ruiz A, Pardal-Peláez B et al. Effect of Rough Surface Platforms on the Mucosal Attachment and the Marginal Bone Loss of Implants: A Dog Study. *Materials (Basel).* 2020;13(3):802. doi: 10.3390/ma13030802. [DOI](#)



6. Laino L, Ciccù M, Russo D, Cervino G. Surgical strategies for multicystic ameloblastoma. *J Craniofac Surg.* 2020;31(2):e116–9. doi: 10.1097/SCS.0000000000005903. [DOI](#)
7. Chen MH, Lyons K, Tawse-Smith A, Ma S. Resonance frequency analysis in assessing implant stability: a retrospective analysis. *Int J Prosthodont.* 2019;32(4):317–26. doi: 10.11607/ijp.6057. [DOI](#)
8. Hsu JT, Shen YW, Kuo CW et al. Impacts of 3D bone-to-implant contact and implant diameter on primary stability of dental implant. *J Formos Med Assoc.* 2017;116(8):582–90. doi: 10.1016/j.jfma.2017.05.005. [DOI](#)
9. Sarfaraz H, Johri S, Sucheta P, Rao S. Study to assess the relationship between insertion torque value and implant stability quotient and its influence on timing of functional implant loading. *J Indian Prosthodont Soc.* 2018;18(2):139–46. doi: 10.4103/jips.jips\_203\_17. [DOI](#)
10. Sheng L, Silvestrin T, Zhan J et al. Replacement of severely traumatized teeth with immediate implants and immediate loading: literature review and case reports. *Dent Traumatol.* 2015;31(6):493–503. doi: 10.1111/edt.12201. [DOI](#)
11. Potapchuk AM, Onipko YL, Almashi VM et al. Experimental study of bone rebuilding in the periimplantation area under immediate loading on dental implants. *Wiad Lek.* 2021;74(4):992–7.
12. Albrektsson T, Wennerberg A. On osseointegration in relation to implant surfaces. 2019;21(1):4–7. doi: 10.1111/cid.12742. [DOI](#)
13. Huang MF, Alfi D, Alfi J, Huang AT. The use of patient-specific implants in oral and maxillofacial surgery. *Oral Maxillofac Surg Clin North Am.* 2019;31(4):593–600. doi: 10.1016/j.coms.2019.07.010. [DOI](#)
14. Juboori MJA, Attas MAA, Gomes RZ, Alanbari BF. Using resonance frequency analysis to compare delayed and immediate progressive loading for implants placed in the posterior maxilla: a pilot study. *Open Dent J.* 2018;12:801–10. doi: 10.2174/1745017901814010801. [DOI](#)
15. Eshkol-Yogev I, Tandlich M, Shapira L. Effect of implant neck design on primary and secondary implant stability in the posterior maxilla: a prospective randomized controlled study. *Clin Oral Implants Res.* 2019;30(12):1220–8. doi: 10.1111/clr.13535. [DOI](#)
16. Fiorillo L, Ciccù M, Tözüm TF et al. Impact of bisphosphonate drugs on dental implant healing and peri-implant hard and soft tissues: a systematic review. *BMC Oral Health.* 2022;22(1):291. doi: 10.1186/s12903-022-02330-y. [DOI](#)
17. Roustit M, Cracowski JL. Assessment of endothelial and neurovascular function in human skin microcirculation. *Trends Pharm.* 2013;34(7):373–384. doi: 10.1016/j.tips.2013.05.007. [DOI](#)
18. Galindo-Moreno P, Concha-Jeronimo A, Lopez-Chaichio L et al. Marginal bone loss around implants with internal hexagonal and internal conical connections: a 12-month randomized pilot study. *J Clin Med.* 2021;10(22):5427. doi: 10.3390/jcm10225427. [DOI](#)
19. Sommer M, Zimmermann J, Grize L, Stübinger S. Marginal bone loss one year after implantation: a systematic review of different loading protocols. *International Journal of Oral and Maxillofacial Surgery.* 2020;49(1):121–134. doi: 10.1016/j.ijom.2019.03.965. [DOI](#)
20. Ide A, Ide S, Sipich O et al. Vymohy do total'noyi protetychnoyi reabilitatsiyi verkhn'oyi shchelepy za tekhnolohiyeyu «Stratehichna implantatsiya» v umovakh protokolu nehaynoho navantazhennya (opys seriyi klinichnykh vypadkiv) [Requirements for total prosthetic rehabilitation of the upper jaw using the «Strategic Implantation» technology under conditions of a careless loading protocol (description of a series of clinical cases).]. *Klinichna stomatolohiya.* 2021;1:4–14. doi: 10.11603/2311-9624.2020.1.12033. (Ukrainian) [DOI](#)
21. Werbelow L, Weiss M, Schramm A. Long-term follow-up of full-arch immediate implant-supported restorations in edentulous jaws: A clinical study. *Int J Implant Dent.* 2020;6(1):34. doi: 10.1186/s40729-020-00232-8. [DOI](#)
22. Salgado-Peralvo AO, Garcia-Sanchez A, Kewalramani N et al. Consensus Report on Preventive Antibiotic Therapy in Dental Implant Procedures: Summary of Recommendations from the Spanish Society of Implants. *Antibiotics (Basel).* 2022;11(5):655. doi: 10.3390/antibiotics11050655. [DOI](#)
23. Guyton A, Hall J. The Microcirculation and the Lymphatic System. In Grulioiw Rebecca. *Textbook of Medical Physiology.* Philadelphia, Pennsylvania: Elsevier Inc. 2012, p.187–8.
24. Ghouth N, Duggal MS, Bani Hani A, Nazzal H. The diagnostic accuracy of laser Doppler flowmetry in assessing pulp blood flow in permanent teeth: A systematic review. *Dent Traumatol.* 2018;34(5):311–319. doi: 10.1111/edt.12424. [DOI](#)
25. Todea C, Cănjău S, Miron M et al. Laser Doppler flowmetry evaluation of the microcirculation in dentistry. In: Helena L, editor. *Microcirculation Revisited – From Molecules to Clinical Practice.* In Tech; London, UK. 2016, p.203–30.
26. Miron MI, Dodenciu D, Sârbescu PF et al. Optimization of the laser Doppler signal acquisition technique in pulp vitality tests. *Arch. Balk. Med. Union.* 2011;46(4):280–4.
27. Hussain RA, Miloro M, Cohen JB. An Update on the Treatment of Periimplantitis. *Dent Clin North Am.* 2021;65(1):43–56. doi: 10.1016/j.cden.2020.09.003. [DOI](#)
28. Sabioni L, De Lorenzo A, Lamas C et al. Systemic microvascular endothelial dysfunction and disease severity in COVID-19 patients: Evaluation by laser Doppler perfusion monitoring and cytokine/chemokine analysis. *Microvasc Res.* 2021;134:104119. doi: 10.1016/j.mvr.2020.104119. [DOI](#)

## CONFLICT OF INTEREST

The Authors declare no conflict of interest

## CORRESPONDING AUTHOR

**Anatoliy Potapchuk**

Uzhhorod National University

16a University Street, 88000 Uzhhorod, Ukraine

e-mail: anatoliy.potapchuk@uzhnu.edu.ua

## ORCID AND CONTRIBUTIONSHIP

Anatoliy Potapchuk: 0000-0001-9857-1407 **A** **B** **E** **F**

Vasyl Almashi: 0000-0002-2943-4844 **A** **B** **C** **E**

Ievgen Onipko: 0000-0002-3086-4657 **B** **D**

Csaba Hegedűs: 0000-0003-4143-2507 **D** **E**

---

**A** – Work concept and design, **B** – Data collection and analysis, **C** – Responsibility for statistical analysis, **D** – Writing the article, **E** – Critical review, **F** – Final approval of the article

**RECEIVED:** 11.11.2023

**ACCEPTED:** 21.02.2024

