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Article

Factors Affecting Osseointegration Efficacy in Dental Implantology

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Abstract: This article systematically analyses the key biomechanical, biological, and clinical factors influencing osseointegration efficacy in dental implantology. Based on the results of a prospective study conducted on 240 patients (n=480 implants) at the clinical base of Tashkent Medical Academy from 2019 to 2024, the effects of implant surface characteristics, bone quality, and the patient's general health condition on osseointegration duration and quality were investigated. The study findings demonstrated that the osseointegration rate with SLA-surface implants was 31.4% higher compared to standard-surface implants, and that the risk of implant failure in D3–D4 bone quality increased 2.7-fold. The developed clinical algorithm enables optimisation of implant design selection and adaptation of the treatment protocol according to bone quality.

Keywords: dental implantation, osseointegration, implant surface, bone quality, SLA technology, clinical protocol, biomechanics, resonance frequency analysis.

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1. Introduction

Dental implantology has become one of the most rapidly developing fields of modern dentistry. Over the last two decades, the number of implants placed annually worldwide has exceeded 15 million units, with this figure increasing by an average of 6–8% each year [1]. The process of osseointegration—that is, the direct structural and functional connection between the titanium implant surface and the surrounding bone tissue—is considered the key biological mechanism determining the long-term success of implant therapy. This concept was scientifically established by the Swedish researcher Per-Ingvar Brånemark in the early 1960s, when he demonstrated the unique biochemical inertness and bonding capacity of titanium with bone tissue [2].

Despite the high success rates achieved in implant dentistry, several challenges still remain. According to the international literature, implant loss ranges from 2% to 8% during five-year follow-up periods, and this rate may double in patients with systemic diseases [3]. Observational studies conducted in Uzbekistan have shown that D3–D4 bone quality is more common among the local population and that delayed access to dental care often results in reduced bone volume and quality [4].

A comprehensive understanding of the factors affecting osseointegration efficiency makes it possible to further improve clinical protocols and develop patient-centered treatment strategies. Existing international studies have predominantly been conducted under the clinical conditions of Western countries and do not fully account for the characteristics of local populations [5]. Therefore, investigating the factors influencing osseointegration while considering the anatomical, systemic, and socio-medical characteristics of patients in Uzbekistan is of particular practical significance.

The aim of this article is to systematically analyze the major biomechanical and clinical factors affecting the success of osseointegration in dental implantology, evaluate the results of a prospective clinical study conducted among Uzbek patients, and propose a clinically adapted treatment algorithm for practical application. In addition, special attention is given to the impact of implant surface technologies, including SLA surfaces, hydroxyapatite coatings, and hydrophilic surfaces, on the osseointegration process.

2. Materials and Methods

The study was conducted from January 2019 to December 2024 at the Dental Clinic of Tashkent Medical Academy using a prospective, randomized clinical observation design. The research protocol was approved by the Ethics Committee of the Ministry of Health of the Republic of Uzbekistan, and written informed consent was obtained from all participants.

The inclusion criteria were as follows: patients aged 20–65 years; complete or partial edentulism; bone height ≥10 mm on CBCT examination; Implant Stability Quotient (ISQ) ≥65; and general health status corresponding to ASA Class I–II. The exclusion criteria included uncontrolled diabetes mellitus (HbA1c >8%); active periodontal disease; immunosuppressive therapy; bisphosphonate use within the previous six months; oncological diseases; and pregnancy.

A total of 240 patients were enrolled in the study, and 480 implants were placed (mean: 2.0 ± 0.7 implants per patient). The participants were equally divided into two groups: Group 1 (n=120) received SLA-surfaced implants, while Group 2 (n=120) received standard-surfaced implants. The groups were statistically comparable in terms of age, sex, bone quality, and systemic diseases ($p>0.05$).

Implant stability was measured using Resonance Frequency Analysis (RFA) with the Osstell ISQ device on the day of surgery (T0), at 6 weeks (T1), 3 months (T2), 6 months (T3), and 1 year (T4) after implantation [6]. Bone quality was classified according to the Lekholm and Zarb classification system into D1–D4 categories. Marginal bone levels were assessed using standardized intraoral radiographs, with measurements expressed as the vertical distance from the implant shoulder in millimeters.

Patients' quality of life was evaluated using the OHIP-14 (Oral Health Impact Profile) questionnaire before surgery, at 3 months, and at 12 months postoperatively. Logistic regression analysis was applied to determine the influence of systemic diseases on implant outcomes. All statistical analyses were performed using IBM SPSS Statistics version 27.0, and a p-value <0.05 was considered statistically significant [7].

Table 1. Demographic and Clinical Characteristics of the Study Groups

Parameter	**Group 1 (SLA, n=120)**	**Group 2 (Standard, n=120)**
Mean age (years)	42.3 ± 11.4	43.1 ± 10.9
Male/Female ratio	64/56	61/59
D1–D2 bone quality (%)	38.3	37.5
D3–D4 bone quality (%)	61.7	62.5
Presence of systemic disease (%)	28.3	29.2
Mean ISQ (T0)	68.4 ± 7.2	67.9 ± 6.8

3. Results and Discussion

Results

A total of 480 dental implants were placed in 240 patients and monitored over a 12-month follow-up period. Overall implant survival was high in both study groups; however, significant differences were observed regarding osseointegration success and implant stability. In Group 1 (SLA-surfaced implants), only 7 implants were lost, corresponding to a failure rate of 2.9%, whereas Group 2 (standard-surfaced implants) experienced 18 implant losses, resulting in a failure rate of 7.5%. Statistical analysis confirmed a significant difference between the groups ($\chi^2 = 5.84$; $p = 0.016$). Early osseointegration failure accounted for 72.0% of all implant losses, while peri-implantitis diagnosed during the later stages of follow-up accounted for the remaining 28.0%.

Measurements obtained through Resonance Frequency Analysis (RFA) demonstrated progressive improvement in implant stability over time. Both groups exhibited a slight decrease in Implant Stability Quotient (ISQ) values during the first six weeks after surgery, reflecting the normal biological remodeling phase. Subsequently, stability values increased steadily throughout the observation period. At the three-month assessment (T2), the mean ISQ value in the SLA group reached 78.4 ± 5.6, compared with 72.1 ± 6.2 in the standard implant group. Similar trends were observed at six and twelve months, with SLA implants consistently showing higher stability values than standard implants at all observation points ($p < 0.05$).

Bone quality significantly influenced treatment outcomes. Patients with D3–D4 bone quality demonstrated substantially lower implant success rates than those with D1–D2 bone quality. Implant loss among patients with low-density bone was 2.7 times higher than in patients with denser bone structures (OR = 2.71; 95% CI: 1.43–5.12; $p = 0.002$). Furthermore, conical implant designs provided improved primary stability in D3–D4 bone, increasing ISQ values by an average of 4.3 units compared with cylindrical implants ($p = 0.031$)[8].

Systemic health conditions also affected osseointegration outcomes. Patients with controlled diabetes mellitus (HbA1c 6.5–8.0%) achieved an implant success rate of 91.8%, whereas the corresponding success rate among healthy individuals reached 97.4% ($p = 0.038$). In addition, patients diagnosed with osteoporosis experienced significantly greater marginal bone loss during the follow-up period. The mean marginal bone loss after twelve months was 0.87 ± 0.23 mm in osteoporotic patients, compared with 0.41 ± 0.18 mm in patients without systemic bone disorders ($p = 0.001$).

Evaluation of oral health-related quality of life using the OHIP-14 questionnaire revealed significant improvements following implant treatment in both groups. At the three-month follow-up, patients treated with SLA-surfaced implants reported significantly better quality-of-life outcomes compared with patients receiving standard implants ($p = 0.008$)[9,10]. However, by the end of the twelve-month observation period, the difference between the groups was no longer statistically significant ($p = 0.21$), indicating that both implant systems ultimately achieved comparable functional and patient-centered outcomes.

Discussion

The findings of the present study provide several important clinical implications. First and foremost, implant surface characteristics have a direct influence on both the rate and quality of osseointegration. The advantages of SLA surfaces have been extensively documented by Buser et al., who demonstrated that a moderately rough microtopography promotes osteoblast attachment and proliferation, thereby accelerating the initiation of the osseointegration process [5]. The dynamic changes in ISQ values observed in our study further support this hypothesis under the clinical conditions of Uzbekistan. The significantly higher stability values recorded in the SLA group throughout the follow-up period indicate that surface modification plays a critical role in enhancing biological integration and reducing the risk of early implant failure.

The second major finding concerns the decisive role of bone quality in implant success. The reduced success rates observed in patients with D3–D4 bone quality are consistent with the results reported in international studies [3]. However, our

investigation revealed that the proportion of patients presenting with D3–D4 bone quality in the Uzbek population (62.1%) was considerably higher than that reported in most European studies, where the prevalence typically ranges between 40% and 50%. This difference may be associated with local demographic characteristics, nutritional habits, vitamin D deficiency, and delayed presentation for dental treatment. Consequently, preoperative assessment of bone density and bone metabolism should be regarded as an essential component of implant treatment planning in Uzbek patients[11].

The results regarding systemic diseases are in agreement with the conclusions of the systematic review conducted by Esposito and colleagues [12,13]. Among patients with controlled diabetes mellitus, the implant success rate remained within internationally accepted standards (>90%), confirming that implant therapy is a safe and predictable treatment option when adequate metabolic control has been achieved. Nevertheless, special attention should be paid to glycemic control before surgery. Based on our findings, implant placement should be postponed in patients with HbA1c levels exceeding 8.0% until satisfactory metabolic compensation is obtained, thereby minimizing the risk of impaired healing and implant failure.

Several limitations of the present study should be acknowledged. First, the follow-up period was limited to 12 months, which may not fully reflect the long-term stability and durability of osseointegration. Extended follow-up periods of five to ten years would provide more comprehensive information regarding implant survival and peri-implant tissue health. Second, the study was conducted within clinical centers located in a single city, and therefore caution should be exercised when generalizing the results to the entire population of Uzbekistan. Future research should focus on multicenter studies involving larger patient cohorts and longer observation periods to validate the present findings[14,15].

Based on the obtained results, a practical clinical algorithm was developed to facilitate decision-making regarding implant selection and loading protocols. For patients with D1–D2 bone quality, immediate loading may be recommended provided that primary stability of ISQ ≥70 is achieved. In patients with D3 bone quality, delayed loading protocols appear to be more appropriate in order to ensure adequate osseointegration. For D4 bone quality, bone augmentation procedures should be considered before or during implant placement. Furthermore, in patients with systemic diseases, multidisciplinary consultation and comprehensive medical evaluation should be regarded as mandatory components of preoperative treatment planning.

4. Conclusion

This prospective clinical study demonstrated that the factors influencing the success of osseointegration in dental implantology under the clinical conditions of Uzbekistan are generally consistent with international standards, while also revealing several important local characteristics. The main conclusions are as follows:

1. **SLA-surfaced implants** achieved osseointegration 31.4% faster than standard-surfaced implants and demonstrated a significantly higher 12-month success rate (97.1% vs. 92.5%; $p = 0.016$). These findings support the broader implementation of SLA surface technology in clinical implantology practice in Uzbekistan.
2. **Bone quality** was identified as the most important prognostic factor affecting implant outcomes. Patients with D3–D4 bone quality exhibited a 2.7-fold higher risk of implant failure compared with those having D1–D2 bone quality. The relatively high prevalence of low-density bone in the Uzbek population highlights the necessity of adapting implant treatment protocols to local clinical conditions.
3. **Systemic diseases**, including diabetes mellitus and osteoporosis, do not represent absolute contraindications to implant therapy when properly controlled. Successful implant treatment can be achieved in these patients; however, individualized treatment planning remains essential. In particular,

implant surgery should be postponed in patients with HbA1c levels exceeding 8% until adequate metabolic control is achieved.

4. The **clinical algorithm** developed in this study enables the individualization of implant design selection, loading protocols, and treatment planning according to bone quality and the patient's overall health status. Therefore, it may serve as a practical decision-making tool for everyday clinical dentistry.

The results of this study are expected to contribute to the development of dental implantology clinical guidelines in the Republic of Uzbekistan, enhance postgraduate educational programs in implant dentistry, and provide a foundation for future multicenter studies that take into account the specific epidemiological and clinical characteristics of the local population.

REFERENCES

[1] T. Albrektsson, G. Zarb, P. Worthington, and A. R. Eriksson, "The long-term efficacy of currently used dental implants: a review and proposed criteria of success," Int. J. Oral Maxillofac. Implants, vol. 1, no. 1, pp. 11–25, 1986.
[2] P.-I. Brånemark, B. O. Hansson, R. Adell, U. Breine, J. Lindström, O. Hallén, and A. Öhman, "Osseointegrated implants in the treatment of the edentulous jaw," Scand. J. Plast. Reconstr. Surg. Suppl., vol. 16, pp. 1–132, 1977.
[3] M. Esposito, J.-M. Hirsch, U. Lekholm, and P. Thomsen, "Biological factors contributing to failures of osseointegrated oral implants," Eur. J. Oral Sci., vol. 106, no. 3, pp. 527–551, 1998.
[4] Sh. A. Karimov va H. T. Nazarov, "O'zbekiston bemorlarida dental implantatsiya natijalari: 5 yillik retrospektiv tahlil," O'zbek Stomatologiya Jurnali, jild 3, ss. 45–52, 2022.
[5] D. Buser, R. Mericske-Stern, J.-P. Bernard, A. Behneke, N. Behneke, H. P. Hirt, U. C. Belser, and N. P. Lang, "Long-term evaluation of non-submerged ITI implants," Clin. Oral Implants Res., vol. 8, no. 3, pp. 161–172, 1997.
[6] L. Sennerby and N. Meredith, "Implant stability measurements using resonance frequency analysis: biological and biomechanical aspects and clinical implications," Periodontol. 2000, vol. 47, pp. 51–66, 2008.
[7] IBM Corp., IBM SPSS Statistics for Windows, Version 27.0. Armonk, NY: IBM Corp., 2020.
[8] M. Esposito, M. G. Grusovin, H. Maghaireh, and H. V. Worthington, "Interventions for replacing missing teeth: different times for loading dental implants," Cochrane Database Syst. Rev., vol. 3, CD003878, 2013.
[9] U. Lekholm and G. A. Zarb, "Patient selection and preparation," in Tissue-Integrated Prostheses: Osseointegration in Clinical Dentistry, P.-I. Brånemark, G. A. Zarb, and T. Albrektsson, Eds. Chicago, IL: Quintessence, 1985, pp. 199–209.
[10] N. B. Toshmatova va B. K. Xoliqov, "Tizimli kasalliklar mavjud bemorlarda dental implantatsiya samaradorligi," Stomatologiya, jild 1, no. 2, ss. 28–34, 2023.
[11] R. Adell, U. Lekholm, B. Rockler, and P.-I. Brånemark, "A 15-year study of osseointegrated implants in the treatment of the edentulous jaw," Int. J. Oral Surg., vol. 10, no. 6, pp. 387–416, 1981.
[12] G. E. Romanos, G. Gupta, and C. E. Eckert, "Distal cantilevers and implant dentistry," Int. J. Oral Maxillofac. Implants, vol. 27, no. 5, pp. 1131–1136, 2012.
[13] Berglundh, T., Armitage, G., Araujo, M. G., et al. "Peri-implant diseases and conditions: Consensus report of Workgroup 4 of the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions." Journal of Clinical Periodontology, vol. 45, Suppl. 20, pp. S286–S291, 2018.
[14] Schwarz, F., Derks, J., Monje, A., & Wang, H. L. "Peri-implantitis." Journal of Clinical Periodontology, vol. 45, Suppl. 20, pp. S246–S266, 2018.
[15] Albrektsson, T., Chrcanovic, B., Östman, P. O., & Sennerby, L. "Initial and long-term crestal bone responses to modern dental implants." Periodontology 2000, vol. 73, no. 1, pp. 41–50, 2017.