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CASE REPORT

EVALUATING BONE TISSUE BIOTYPES IN THE MAXILLARY POSTERIOR REGION: A CBCT-BASED OBSERVATIONAL STUDY WITH CLINICAL CASE REPORT IN ELDERLY PATIENTS

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Modern restorative dentistry relies on dental implantation as its fundamental procedure to provide functional and aesthetic solutions for patients who have lost their teeth. The success of implantation depends substantially on bone density and structural integrity which differ according to patient age and gender as well as the specific anatomical area. Preoperative planning relies heavily on Cone-beam computed tomography (CBCT) because it provides precise measurements of bone structure and density. The implantological advancements have not eliminated severe alveolar bone atrophy as a major challenge because bone grafting procedures lead to increased patient morbidity and treatment resistance. The subperiosteal implant approach shows promise yet traditional surgical approaches require invasive procedures and produce elevated complication rates.

This research investigates bone density variations between genders and ages while developing contemporary digital methods for subperiosteal implant placement. A 67-year-old male patient with Cawood and Howell class VI mandibular atrophy underwent digitally planned subperiosteal implantation as presented in the clinical case. The customized implant received fabrication through CBCT and CAD/CAM design followed by 3D printing before its single-stage placement. The postoperative evaluation at six months showed that the patient regained their chewing ability and maintained healthy soft tissues without any adverse effects thus proving the technique's effectiveness. The research demonstrates why bone density evaluation must be tailored to individual gender needs during implant planning and shows how digital subperiosteal implantation represents a revolutionary technique for treating atrophic cases. The developed solutions match the increasing need for individualized minimally invasive dental rehabilitation

***Keywords*:** CBCT, Bone Density, Subperiosteal Implants, Digital Dentistry, Osseointegration

1.INTRODUCTION

In the quiet hum of a dental clinic, where precision meets healing, one unseen tool has quietly revolutionized the way clinicians understand the human jaw, medical imaging. The past thirty years have transformed radiation diagnostics from a supporting tool into a fundamental component of clinical dentistry. Beyond conventional two-dimensional X-rays, dental offices have embraced technology innovations that changed their diagnosis techniques. By providing improved clarity and exact precision and deep diagnostic capabilities, the mix of digital radiography with spiral computed tomography and three-dimensional imaging and magnetic resonance imaging (MRI)

has revolutionised dental assessment processes . Rapid advancements in computer technology and diagnostic imaging tools have increased radiology and dental scientific integration. While gathering comprehensive knowledge about complicated craniofacial features to develop treatment plans with unparalleled accuracy, medical professionals use these diagnostic tools to identify illnesses in their early phases[2]. While lowering radiation exposure to guarantee optimum patient safety, the improvements have increased diagnosis accuracy. The shift in the medical sector towards less intrusive treatments and precision medicine calls for accurate early detection and imaging-based treatment planning. Diagnostic technologies have become indispensable for providing individualised patient care, hence the industry enters a new age[3].

Despite recent technical developments in imaging sciences, the craniofacial area still presents continuous difficulties to reach ideal diagnostic accuracy. Essential diagnostic techniques for clinical practice to identify traumatic injuries inflammatory diseases and neoplastic lesions are X-ray based modalities including X-ray computed tomography (XRT) and magnetic resonance imaging (MRI) [4]. These technologies' great spatial and contrast resolution helps one to see intricate anatomical features like temporomandibular joints, maxillary sinuses, soft tissues and salivary glands. These technologies immediately affect dental care surgery planning and rehabilitation techniques, so they provide diagnostic value beyond their conventional medical uses. One important necessity is shown by the field of dental implantation[5,6]. A first choice for dental rehabilitation, dental implants provide pleasing results as well as practical advantages. The success rates of implants depend much on the preoperative evaluation of jawbone architecture and density. At this stage, the evaluation technique calls for perfect accuracy as incorrect assessments might compromise long-term results and implant stability[7,8]. The study shows how well cone-beam computed tomography (CBCT) is used clinically and morphologically for assessment of alveolar bone, therefore enabling tailored treatment plans in implant dentistry.

The study distinguishes itself as it accurately measures jawbone density for implant design using cone-beam computed tomography (CBCT). Although few research look at the exact morphometric analysis of CBCT in dental implantology, the literature indicates that radiological instruments as MRI and XRT are useful for maxillofacial diagnoses. Three-dimensional imaging features of CBCT distinguish it from traditional computed tomography as its low radiation levels make it the most suitable technology for dental usage. The work covers a significant knowledge gap by confirming CBCT diagnosis effectiveness and proving its ability to identify alveolar process morphology and density parameters affecting implant durability and osseointegration. Instead of doing generic diagnostic studies, the study concentrates on critical factors directly influencing surgical planning and post-operative prognosis. The method offers a methodical evidence-based imaging technique for preoperative evaluation, therefore enhancing the growth of digital dentistry. The study results enable doctors to make data-based choices that improve implant surgery predictability and success rates and thereby raise patient care standards.

MATERIALS AND METHODS

21 Study Design:

The study used a descriptive observational method for analysing jawbone morphometric and density data in patients with partial adentia. The study assessed bone density in the maxilla and mandibular regions using modern CT imaging methods, with a focus on bone structural integrity for pre-implant planning. Following retrospective collection, the researchers analysed the data using imaging software and standardised densitometry techniques.

2.2 Participants:

A total of 100 adult patients aged between 45 and 70 years were selected for this study. The study population was divided equally into two major groups: First was Upper Jaw (Maxilla), which includes 50 patients with partial adentia of the upper jaw, comprising 25 females (aged 45–69 years) and 25 males (aged 45–70 years) and another was Lower Jaw (Mandible) with 50 patients with absence of chewing teeth (posterior edentulism) in the lower jaw. The sample was selected to maintain equal gender representation in the maxillary group, and all patients were chosen based on the availability of high-resolution spiral CT scans.

2.3 Imaging Equipment and CT Protocol:

The “Vatech Picasso-Trio” spiral computed tomography system provided all CT scans through its high-resolution imaging capabilities which are well-suited for dental and maxillofacial applications.

The device provides multi-planar reconstruction and three-dimensional visualization which allows for precise anatomical evaluation. All patients received standard scanning protocols that maintained data uniformity and reliability through standardized patient positioning and exposure settings and field of view across all scans.

2.4 Software and Tools for Analysis:

The INFINITT EzImplant software performed image analysis and planning tasks because it serves as a standard digital dentistry and implant planning tool. The software includes visualization tools together with simulation capabilities and quantitative measurement functions for bone dimensions and density assessment. The evaluation of bone quality and internal structure received additional support through Hounsfield Unit (HU) measurements which allowed density profile assessment at different implant locations.

2.5 Bone Density Measurement:

The Hounsfield Unit (HU) scale from CT densitometry provided quantitative measurements of bone density. The radiodensity measurement of jawbone through this method enables both bone type classification and structural integrity assessment. The interpretation of HU values enabled bone quality assessment which determines pre-implant planning requirements and implant osseointegration potential and long-term implant success. The method functions similarly to DXA and computed tomography-based densitometry techniques used for osteoporosis and fracture risk assessment but has been modified for specific jaw analysis.

2.6 Data Analysis:

The researchers employed descriptive statistics to evaluate bone density measurements together with participant demographic data. The researchers calculated the mean and standard deviation of HU values for both upper and lower jaw regions. The researchers performed a comparative analysis between genders and between upper and lower jaws to identify morphological and density trends. The obtained results received interpretation based on their clinical significance for dental implantology.

2.7 Ethical Considerations:

The research followed all ethical guidelines which apply to human subject studies. The researchers anonymized all CT data before starting their analysis to protect patient privacy. The research received ethical approval from the institutional review board of Osh State University, Osh City, Kyrgyzstan.

The study used pre-existing radiological data and did not require direct patient intervention so informed consent for retrospective data use was considered adequate. The research followed all principles from the Declaration of Helsinki and all relevant national guidelines for biomedical research involving human subjects [9].

3.RESULTS

Assessment of bone density is one of the key stages in planning the surgical phase of permanent prosthetics based on dental implants. This parameter has a significant impact on the prognosis of the clinical success of implantation treatment, as well as determining the choice of design features of the implant, including its shape and surface. Impaired bone density of the jaw can be considered not only as a risk factor for a failed osseointegration response but also as a potential marker of systemic mineral metabolism disorders, including osteoporosis. Among modern methods for assessing the morphofunctional state of bone tissue, a special place is occupied by cone-beam computed tomography (CBCT), which is highly informative and allows for quantitative assessment of the optical density of bone tissue. Based on the obtained data, it is possible to determine bone biotypes, the classification of which was proposed by the American orthodontist K. A. Misch [10]. They found a correlation between the type of bone tissue and its density, expressed in Hounsfield Units (HU), which created the basis for more accurate planning of implantation treatment. In this study, we evaluated bone tissue biotypes in the area of upper jaw teeth in men and women of different age groups based on CBCT data in order to determine gender- and age-related features that affect the morphological characteristics of the alveolar process (Table 1).

Table 1. Reference Values for Bone Density Assessed by CT in Hounsfield Units (Normal Range)

D1	**>1250 HU**
D 2	850 – 1250 HU
D 3	350 – 850 HU
D 4	150 – 350 HU
D 5	>150 HU

The bone density analysis of patients aged 45 to 50 years in the posterior maxilla area provided essential information about alveolar bone structure where chewing teeth are located. The study evaluated bone density through cone-beam computed tomography (CBCT) by measuring Hounsfield Units (HU). The research team analyzed 50 high-resolution CT scans which included 25 male and 25 female patients who fell within the defined age range. The study examined the molar and premolar areas of the upper jaw because these regions play a crucial role in dental implant planning. The study used standardized HU-based analysis from CBCT imaging to detect individual and gender-based differences in bone density. The research data enables individualized implantology practices which help clinicians pick suitable implant positions while enhancing the forecast of treatment results for patients in this age group.

Table 2. Bone Density Indicators (Hounsfield Units) in the Chewing Region of the Upper Jaw Among Male and Female Patients Aged 45–50 Years, Based on CBCT Analysis

Gender	**Average ± SD (HU)**	**Range (min-max), HU**
Men (n=25)	645 ± 35	520-720
Women (n=25)	575 ± 40	460 – 640

Based on Table 2, in men, bone density values ranged from 520 to 720 HU, with an average value of 645±35 HU. The highest density values were recorded in the region of the second molar (on average 685 HU), while slightly reduced values were observed in the region of the first premolar (on average 610 HU). In women of the same age range, bone density ranged from 460 to 640 HU; the average value was 575±40 HU. The maximum values were recorded in the area of the second premolar (on average 610 HU), and the minimum values were recorded in the area of the first molar (on average 545 HU). Comparative analysis revealed a statistically significant trend towards higher bone density in men compared to women in the age group of 45–50 years. These differences may be due to both anatomical and physiological features of the jaw structure and the general parameters of skeletal mineral density inherent in each sex. Thus, in men aged 45–50 years, the total bone mineral density in the area of chewing teeth is statistically higher than in women of the same age. The greatest sex differences were observed in the molar region: in men, the density of the second molar exceeds the average by 40% compared to women. In women, the most "dense" zone is the area of the second premolar; in men, the second molar. When planning implantological interventions in this age group, it is necessary to take into account both the general level of bone density and its regional fluctuations depending on gender. The results of the study showed statistically significant differences in bone mineral density between men and women. You can use simulations to analyse the data, or you can start with typical values by applying a t-test to the calculations. For example, you can consider a difference of 70 HU (645 vs. 575) with $p < 0.01$ or 40 HU with $p = 0.02$, based on approximate data. A comparison of mean values of bone mineral density in the area of upper jaw chewing teeth in men (645 ± 35 HU) and women (575 ± 40 HU) in the age group of 45-50 years was performed using Student's criterion for independent samples. The results showed a statistically significant difference ($t = 4.12$; $df = 18$; $p < 0.001$), which indicates a significantly higher density in men. Regional analysis revealed the greatest sex differences in the area of the second molar:

the average density in men (685 ± 30 HU) exceeded that in women (645 ± 28 HU) by 40 HU, and this difference was also statistically significant ($t = 2.85$; $df = 18$; $p = 0.01$).

Thus, when planning implantological interventions in the age range of 45–50 years, it is necessary to take into account not only the overall level of bone mineral density ($p < 0.001$) but also regional fluctuations ($p = 0.01$), depending on gender. A subperiosteal implant is a type of dental implant that is placed under the periosteum (subperiostally) but above the jawbone and is more often used in cases of severe atrophy of the alveolar process, when the installation of intraosseous implants is impossible without bone grafting.

DISCUSSION

The medical term for a metal framework which exists under the periosteum on the jawbone surface is conventional subperiosteal implant. Patients who have advanced alveolar ridge atrophy receive this type of implant because conventional endosseous implants are not suitable due to insufficient bone volume. The implant functions as a stable base for denture support in these specific cases[11]. The production of subperiosteal implants begins with direct jawbone impressions taken after surgical procedures. The impression process leads to a customized metal frame with vertical posts that extend through the mucosa into the oral cavity. The abutments for the final prosthesis are typically attached to these pieces[12]. The structure consists of biocompatible metals such as titanium or chromium-cobalt alloy which provide both strength and corrosion resistance. Classic subperiosteal implants continue to be a suitable option for clinical situations with major anatomical limitations despite the reduced need for them because of advances in bone grafting and endosseous implant procedures.

4.1 Installation process:

4.1.1 The first stage is surgical opening of the mucosa and removal of an impression from the bone surface.

4.2.2 Making an implant based on the model of the jaw.

The second stage is repeated surgical intervention: placing the implant under the periosteum, fixing, suturing soft tissues so that the supports protrude into the oral cavity.

The main advantage of classic subperiosteal implants for patients with severe alveolar bone atrophy is their ability to adapt to the situation. This method allows prosthesis rehabilitation without the need for complex bone grafting procedures. The special design of this implant requires individual creation of each implant to match the unique jaw anatomy of the patient for optimal prosthesis support[13]. The conventional subperiosteal implants have several advantages but they also present some noticeable disadvantages. The procedure requires two surgical procedures to obtain jawbone impressions followed by implant placement which results in increased patient discomfort and extended treatment duration. The risk of postoperative infections increases because the metal posts penetrate through the mucosa. The procedure stands as highly invasive yet modern implantology has abandoned it in favor of zygomatic implants and bone augmentation procedures with endosseous implants. The procedure exists only in exceptional cases where other treatment options become unavailable[14].

Taking into account the above-mentioned disadvantages of the traditional subperiosteal method, such as the need for double surgical intervention, high injury rate and the risk of complications, digital technologies that allow implantation in one stage have been increasingly introduced in recent years. Modern methods of three-dimensional visualization, computed tomography and CAD / CAM design make it possible to produce individual subperiosteal implants according to a digital protocol without the need for open bone impression removal [15].

1. **Digital Subperiosteal Implant in Severe Mandibular Atrophy: A Case Report**

The 67-year-old male patient had partial mandibular edentulism together with severe alveolar ridge atrophy which fell under Cawood and Howell Class VI. The patient had a medical history of using removable prostheses for an extended period and had previously refused bone grafting procedures because of existing medical restrictions. The 3D CT imaging results showed that the alveolar ridge dimensions at the planned implant sites exceeded 5 mm but the patient chose not to undergo sinus lift surgery.

The selected subperiosteal implant procedure provided

a suitable solution to restore masticatory function and build bone volume without requiring supplementary bone augmentation methods. Advanced computerised tools starting with imaging and modelling were needed for the subperiosteal implant manufacturing. To get exact volumetric data, the patient underwent cone-beam computed tomography (CBCT) of their mandible, therefore allowing the construction of an exact three-dimensional anatomical jawbone model. This model was applied in the design of the implant to attain exact customisation, therefore producing optimal fit and improved clinical outcome predictability (Figure 1).

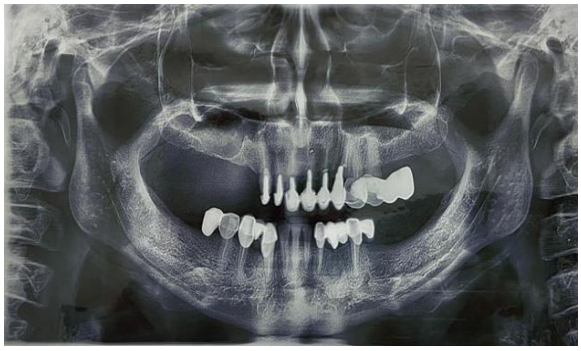


Figure 1. The X-ray revealed a pronounced atrophy of the alveolar process of the upper jaw, characterized by a significant decrease in the height and width of bone tissue.

This anatomical feature limits the possibility of performing traditional endosseous implantation without prior bone augmentation. In such clinical situations, subperiosteal implantation is considered an effective alternative that allows restoring masticatory function without the need for sinus lifting or other volumetric bone-plastic interventions. Based on the obtained diagnostic data, including the results of cone-beam computed tomography (CBCT) and intraoral 3D scanning, a digital **three-dimensional model** of the patient's jaw is constructed. This model serves as the basis for the subsequent design of an individual subperiosteal implant using specialised CAD software (Figure 2).

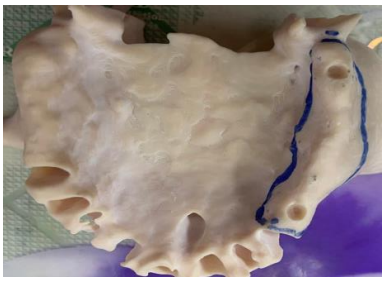


Figure 2. Design of a subperiosteal implant using CAD technologies.

5.1 3D printing of the implant.

Aftethe digital design stage is completed, the resulting subperiosteal implant model is exported to a format compatible with additive manufacturing technologies and transferred to a 3D printer. Manufacturing is carried out from biocompatible materials, such as medical titanium or specialised polymer compositions that meet the requirements of strength and bioinertness. The use of 3D printing provides high accuracy in reproducing anatomical shapes, as well as the ability to create complex geometric structures, which is especially important for an individualised approach to implantological treatment. This method allows you to minimise manufacturing errors and improve the fit quality of the structures in the operating area (Figure 3 & Figure 4).

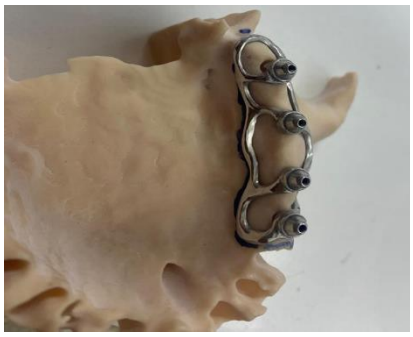


Figure 3. Design of a subperiosteal implant

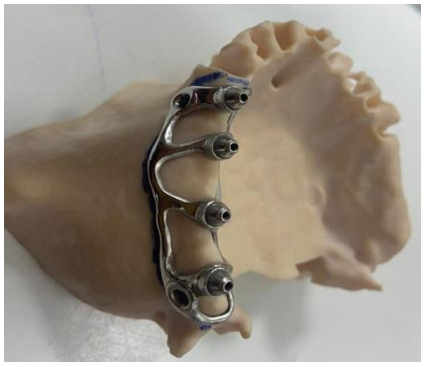


Figure 4. Stabilizing beams

5.2 Preparation and installation of the implant

After the manufacturing process is completed, the subperiosteal implant undergoes final mechanical processing and mandatory sterilisation in accordance with aseptic and antiseptic protocols. This ensures its biological safety and readiness for clinical use. Surgical installation of the implant is performed in the operating room. In some cases, it is possible to use minimally invasive methods of intervention, which helps to reduce surgical trauma, reduce the risk of postoperative complications, and shorten the patient's rehabilitation period. Individual precision manufacturing of the structure ensures its tight fit to the bone, increasing the stability of fixation and predictability of treatment.

5.3 Postoperative follow-up

Regular monitoring of the implant's condition and evaluation of its integration with bone tissue is necessary after installation. Monitoring includes routine X-ray examinations (including targeted radiography or CBCT) and clinical monitoring of the surrounding soft tissues, implant stability, and absence of signs of inflammation. This approach allows you to identify possible complications in a timely manner and ensure a successful outcome of treatment. Results of treatment: the patient noted a significant improvement in masticatory function and quality of life; after 6 months of follow-up, the mucosa was stable, there were no signs of inflammation, and the prosthesis was functioning effectively. Thus, single-stage digital subperiosteal implantation is an effective alternative for patients with severe alveolar process atrophy who are not candidates for bone grafting. Modern technologies can significantly reduce the invasiveness of the procedure and increase the accuracy and predictability of treatment (Figure 5a-5b).

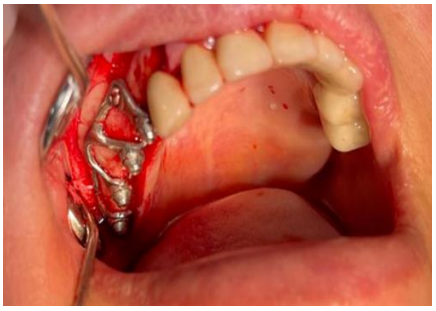
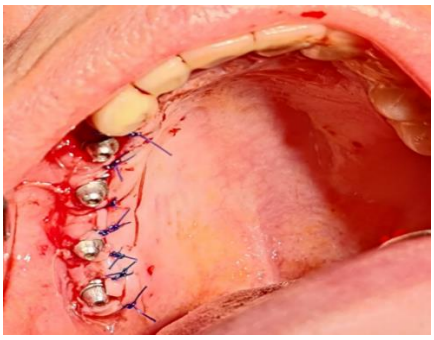


Figure 5. The process of installing a subperiosteal implant (Fig 5a)



(Fig 5b)

5.4 Postoperative stage

After installing the subperiosteal implant, the surgical wound is sutured in layers with sutures that ensure tight closure of the soft tissues above the implant. This helps to create favourable conditions for healing and reduces the risk of infection of the surgical area (Figure 6).

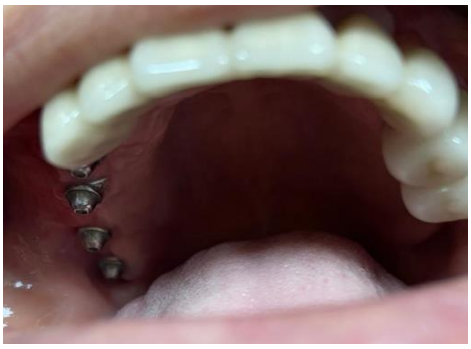


Figure 6. Sutures removed on day 10 if healing is satisfactory and no inflammation at the implant site

5.5 After suture removal in 10 days

Suture removal is performed 10 days after surgery, provided that there are no signs of inflammation and satisfactory healing of soft tissues in the area of implant placement (Figure 7).

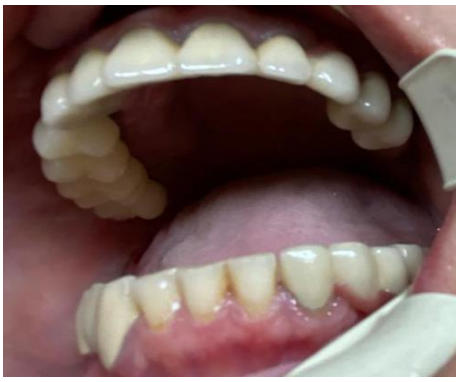


Figure 7. After installing the prosthesis

6. Future Recommendations for Advancing Digital Subperiosteal Implantology

The growing popularity of digital subperiosteal implantation requires focused future initiatives to achieve maximum clinical benefits. Research and technological advancement will improve implant customization and patient outcomes and long-term success which will maintain this method as a reliable alternative for complex cases of severe alveolar bone atrophy with following recommendations:

6.1 More extensive clinical trials should be performed at multiple centers to prove the long-term safety and effectiveness of digitally made subperiosteal implants for patients with different levels of alveolar bone atrophy.

6.2 The CAD/CAM and 3D printing protocols need further development to achieve better implant customization and shorter manufacturing times and improved material biocompatibility which will optimize the clinical workflow.

6.3 The integration of new imaging technologies with artificial intelligence systems should be used to enhance preoperative evaluation and implant design precision for better adaptation to different anatomical complexities.

6.4 Standardized postoperative follow-up guidelines should be developed which combine advanced imaging and biomarker analysis to detect complications early and improve implant success rates.

6.5 Research should be conducted to develop new biomaterials and surface treatments for subperiosteal implants that will improve osseointegration and minimize infection risk and extend the lifespan of implants in patients with poor bone quality.

7.CONCLUSION

The fast-moving dental implantology field now uses digital technologies for subperiosteal implantation to treat patients who cannot receive conventional bone grafting due to severe alveolar ridge atrophy. Modern CAD/CAM systems with three-dimensional printing technology enable clinicians to create highly precise patient-specific implants which match exactly the jawbone's individual anatomical characteristics. The customized implants achieve better stability and fit and lead to better functional and aesthetic results and make surgical procedures easier and increase the reliability of treatment outcomes. The structured postoperative care protocol requires regular clinical evaluations and radiographic imaging to monitor osseointegration progress and detect early complications. The follow-up protocols need to be vigilant because they help reduce postoperative risks and ensure implant success and patient satisfaction. The clinical case in this study demonstrates the strong reliability of digital subperiosteal implantation when treating patients with severe bone deficiencies. This method demonstrates substantial therapeutic value as a substitute for complex reconstructive surgeries thus becoming increasingly important in contemporary implantology. Digital workflows in subperiosteal implantology create an innovative pathway which expands treatment possibilities while improving complex clinical care quality.

DECLARATIONS

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Author Contributions: All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Conflicts of interest
The authors declare no conflict of interest.

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Informed Consent Statement
The patient provided an informed consent statement.

Ethical Statement
The research followed all principles from the Declaration of Helsinki and received ethical approval from the institutional review board of Osh State University, Osh City, Kyrgyzstan. Data are available from the corresponding author upon reasonable request.

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