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CASE REPORT
PRIKAZ SLUČAJA

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Volumetric Changes of a Customized Allogeneic Bone Block Measured by Two Image Matching Tools: Introduction of a Novel Assessment Technique for Graft Resorption

Promjena volumena individualnog alogenog koštanog bloka mjerena pomoću dva softverska alata: nova tehnika za procjenu resorpcije grafta

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Abstract
Objective: The purpose of this case report was to present a method for the assessment of volumetric changes of bone blocks during healing and demonstrate its practicability by analysing the resorption of a pre-shaped allogeneic bone block used for the reconstruction of a complex maxillary defect. **Materials and methods:** CBCT-scans of a 19-year-old male treated with an allogeneic bone block were recorded pre-OP, post-OP, and following six months of healing. Graft shrinkage was assessed via two image matching tools, namely coDiagnostiX® and Slicer. A biopsy specimen was harvested along the implant canal at the time of implantation. **Results:** The osseous defect was successfully restored and advanced graft remodelling was found upon re-entry as confirmed by the histomorphometric and histologic analysis. The initial volumes of the graft determined via coDiagnostiX® and Slicer were 0.373 mL and 0.370 mL., respectively, while graft resorption after six months of healing was 0.011 mL (3.00%) and 0.016 mL (4.33%). **Conclusions:** The avoidance of bone harvesting and reduction of invasiveness display an important issue in dentoalveolar restorations. However, before grafting materials can be considered a safe alternative, understanding their clinical performance, especially resorption stability, is pivotal. The present case report demonstrates a limited resorption of the allogeneic bone block and further emphasizes the practicability of determining bone resorption by the here introduced method. As our investigation comprises solely one subject, the results should be considered with care and substantiated by further studies.

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Introduction

Dental implants are an integral part of modern dentistry and represent the benchmark regarding esthetics, and consequently patient satisfaction (1, 2). Since edentulism, which may occur due to traumata or disease, severely affects the jaw's morphology by causing ongoing bone resorption, various techniques and materials have been added to the surgeon's portfolio for the regeneration of the alveolar crest (3, 6). The authors of an analysis of 10158 implants who found a grafting frequency of 58.2% emphasized the important role of bone grafting in modern dentistry (7).

Uvod

Zubni implantati sastavni su dio suvremene dentalne medicine i mjerilo su kad je riječ o estetici, pa tako i zadovoljstvu pacijenata (1, 2). Budući da bezubost, koja se može pojaviti zbog traume ili bolesti, ozbiljno utječe na morfologiju čeljusti uzrokujući kontinuiranu resorpciju kosti, u portfelj kirurga dodane su različite tehnike i materijali za regeneraciju alveolarnoga grebena (3, 6). Autori analize 10158 implantata koji su utvrdili učestalost transplantacija od 58,2 % istaknuli su važnost presađivanja kosti u suvremenoj dentalnoj medicini (7).

While contained and minor bone defects are predictably restorable with a broad selection of bone substitute materials, extensive defects require additional means for graft stabilization, which may either be maintained by barrier membranes, titanium meshes, bone shells or solid bone blocks (8-10). Complex augmentations within the esthetic zone are especially challenging since high long-term volume stability of the grafting material is required to ensure an esthetic appearance. While autogenous bone grafts are considered the gold standard in bone grafting, several authors have reported similar rates in bone gain, especially regarding horizontal dimensions grafting success and implant survival for allogeneic bone blocks (11-15). Several studies have demonstrated that patients prefer surgery with lower invasiveness, had lower acceptance for extra- as compared to intraoral bone harvesting, and were more willing to undergo a secondary bone augmentation with allogeneic than with autogenous bone blocks (16,17). Additionally, the authors demonstrated comparable success rates and pink esthetic scores for both treatment groups (18). These encouraging findings have led to a greater acceptance of allogeneic bone grafts in oral surgery regarding both surgeons and patients (19, 20).

Allografts are categorized into fresh-frozen bone (FFBA), freeze–dried bone (FDBA) and demineralized freeze–dried bone allografts (DFDBA), (21). FDBA and DFDBA are considered a safe alternative to autogenous bone grafts, whereas immunization and disease transmission associated with the application of FFBA has previously been reported (22-24). In this context, a literature review carried out by the World Health Organization found no reports of disease transmission associated with wet-chemically processed allografts, and also no reports of disease transmission associated with FFBA after the introduction of nucleic-acid testing (25). Various authors have demonstrated low graft resorption acompanied by high grafting success and implant survival rates (26-29).

The computer-aided design / computer-aided manufacturing (CAD/ CAM) technology has enabled the manufacturing of individualized dental materials such as polymethyl methacrylate or allogenic bone blocks via cone beam computed tomography (CBCT) datasets (30-32). A bone mortiser is then used to mill the bone in accordance with the digital design, so that the block matches the defect's morphology precisely. The accuracy of this manufacturing process renders manual adjustments of bone blocks largely unnecessary, and consequently lowers the risk of complications and graft contamination (19, 33). In addition, the customization process minimizes the space between the allogeneic block graft and the host bone which promotes trophic support and graft vascularization (20, 34, 35).

Previous authors have reported bone resorption of 3.9 ± 5.6% and 4.2 ± 5.5% for manually adapted monocortical autogenous and allogeneic bone blocks, respectively. In these studies, dimensional changes were assessed by geometrical measurements (36). Nevertheless, limited literature is available on the initial resorption and remodeling capacity of allogenic bone blocks. The purpose of this case report was to present a two-factor method for digitally assessing the volumetric changes of bone grafts during graft consolidation as

Dok se ograničeni i manji koštani defekti mogu predvidljivo rekonstruirati širokim izborom materijala za nadomještanje kosti, oni opsežni zahtijevaju dodatna sredstva za stabilizaciju transplantata, a to mogu biti barijerne membrane, titanijeve mrežice, koštane školjke ili solidni koštani blokovi (8 – 10). Kompleksne augmentacije u estetskoj zoni posebno su izazovne jer je potrebna visoka dugoročna volumna stabilnost transplantata kako bi se osigurao estetski izgled. Dok se autogeni koštani transplantati smatraju zlatnim standardom u koštanom presađivanju, nekoliko je autora izvijestilo o sličnim stopama koštanoga dobitka, posebno kad je riječ o uspjehu augmentacije horizontalnih dimenzija i preživljavanja implantata za alogene koštane blokove (11 – 15). U nekoliko istraživanja istaknuto je da pacijenti preferiraju operacije s manjom invazivnošću, da rjeđe prihvaćaju ekstraoralna uzimanja kosti u usporedbi s intraoralnima i da su spremniji podvrgnuti se sekundarnoj augmentaciji kosti s alogenim koštanim blokovima negoli autogenima (16, 17). Uz to autori su pokazali usporedive stope uspjeha i za ružičastu estetiku za obje skupine liječenja (18). Ti ohrabrujući nalazi potaknuli su veće prihvaćanje alogenih koštanih transplantata u oralnoj kirurgiji i kod kirurga i kod pacijenata (19, 20).

Alogeni transplantati kategoriziraju se u svježe zamrznutu kost (FFBA), smrznutu kost (FDBA) i demineralizirane zamrznute osušene alogene transplantate (DFDBA), (21). FDBA i DFDBA smatraju se sigurnom alternativom za autogene koštane transplantate, a imunizacija i prijenos bolesti povezan s primjenom FFBA-e prethodno je zabilježen (22 – 24). U tom kontekstu, tijekom pregleda literature koji je obavila Svjetska zdravstvena organizacija nisu pronađeni izvještaji o prijenosu bolesti povezanih s mokro kemijski obrađenim alotransplantatima, ni izvješća o prijenosu bolesti povezanih s FFBA-om nakon uvođenja testiranja nukleinskih kiselina (25). Različiti su autori istaknuli nisku resorpciju transplantata praćenu visokim uspjehom presađivanja i stopom preživljavanja implantata (26 – 29).

Tehnologija računalno pomognutog dizajna / računalno pomognute proizvodnje (CAD/CAM) omogućila je proizvodnju individualiziranih dentalnih materijala kao što su polimetil-metakrilat ili alogeni koštani blokovi na temelju seta podataka CBCT-a (30 – 32). Zatim se glodalica za kost upotrebljava za obradu kosti u skladu s digitalnim dizajnom tako da blok točno odgovara morfologiji defekta. Točnost toga proizvodnog procesa čini ručne prilagodbe koštanih blokova uvelike nepotrebnima, a time se smanjuje i rizik od komplikacija i kontaminacije transplantata (19, 33). Uz to proces prilagodbe minimizira prostor između alogenoga blok-transplantata i kosti domaćina, što potiče trofičku potporu i vaskularizaciju transplantata (20, 34, 35).

Prethodno su autori izvijestili o resorpciji kosti od 3,9 ± 5,6%, odnosno 4,2 ± 5,5% za ručno prilagođene monokortikalne autogene i alogene koštane blokove. U tim su istraživanjima promjene dimenzija procijenjene geometrijskim mjerenjima (36). Ipak, postoji ograničena literatura o početnoj resorpciji i kapacitetu remodeliranja alogenih koštanih blokova. Svrha ovog prikaza slučaja bila je predstaviti dvofaktorsku metodu za digitalnu procjenu volumetrijskih promjena koštanih transplantata tijekom njihove konsolidacije, što je

demonstrated by a customized allogeneic bone block, which was applied for the augmentation of a complex osseous defect in the maxillary esthetic zone.

Case Presentation and Surgical Procedure

A 19–year–old male suffering from Hirschsprung's disease (HSCR) and attention deficit hyperactivity disorder (ADHD) presented with the desire for a fixed prosthetic rehabilitation of the congenitally missing permanent tooth #7 (ADA Dental Terminology 2011–2012) in the maxillary esthetic zone (Figure 1 A). During the clinical and radiographic examination of the jaw, an extensive bone deficit was identified in the edentulous area which required bone augmentation prior to implantation. The patient was a non-smoker with healthy soft tissue and good oral hygiene so that the overall health status did not contraindicate alveolar bone grafting. As the patient opposed intraoral bone harvesting, a CAD/CAM manufactured bone block (maxgraft bonebuilder®, botiss biomaterials GmbH, Zossen, Germany) made of cancellous freeze-dried bone allograft was applied (Figure 1 B, C). The graft was obtained from femoral heads of living donors who underwent arthroplastic surgery. Prior to treatment, the patient gave his informed consent for the inclusion into scientific publications.

The bone augmentation procedure was conducted under general anesthesia upon the patient's request. Prior to bone augmentation, platelet–rich plasma (PRP) matrices were generated from the patient's blood and 600 mg of Clindamycin were intravenously administered for antibiotic prophylaxis (37). An incision design recently introduced by our group termed the "semi-pillar incision" was applied to enter the defect site (35, 38). Instead of a mid-crestal position, the horizontal incision was placed about 20 mm to the buccal site within the flexible mucosa and only one vertical releasing incision was added at the distal end of the horizontal incision line. Subsequently, the vestibular mucosal flap was carefully mobilized, and the periosteum was elevated from the maxillary bone so that the keratinized mucosa above the defect remained undamaged (Figure 2 A). This approach facilitates tension-free covering of grafts with extensive volumes and, consequently lowers the risk of wound dehiscences and associated complications.

Before the insertion of the allogeneic bone block, the cortical layer of the recipient site was perforated multiple times by means of a diamond burr to induce bleeding and enhance graft vascularization (34). The block was hydrated in exudate serum which was obtained during production of the PRP matrices (Figure 2 B). Since the block matched the defect's geometry exactly, no additional adjustments were required. Additionally, due to the optimal fit of the block within the recipient site, a single 9 mm titanium osteosynthesis screw with a diameter of 1.5 mm was sufficient for graft fixation (Figure 2 C). For the prevention of pressure exerted by the screw-head and the concomitant graft resorption, a countersink for the screw head was created. Due to a pronounced over-contouring, which was planned intentionally though, a thin layer on the vestibular site of the block was abraded and then covered

prikazano prilagođenim alogenim koštanim blokom koji je primijenjen za rekonstrukciju složenoga koštanoga defekta u maksilarnoj estetskoj zoni.

Prikaz slučaja i kirurški postupak

Muškarac u dobi od 19 godina koji boluje od Hirschsprungove bolesti (HSCR) i poremećaja pažnje ili pozornosti te hiperaktivnosti (ADHD) pojavio se sa željom za fiksnom protetičkom rehabilitacijom kongenitalno nedostajućega trajnog zuba #7 (ADA Dental Terminology 2011.–2012.) u estetskoj zoni (slika 1.a). Tijekom kliničkog i radiološkog pregleda čeljusti uočen je opsežan koštani deficit u bezubom području koji je zahtijevao augmentaciju kosti prije implantacije. Pacijent je bio nepušač sa zdravim mekim tkivom i dobrom oralnom higijenom tako da cjelokupno zdravstveno stanje nije kontraindiciralo presađivanje alveolarne kosti. Budući da se protivio intraoralnom uzimanju kosti, upotrijebljen je koštani blok proizveden CAD/CAM-om (maxgraft bonebuilder®, botiss biomaterials GmbH, Zossen, Njemačka) od spužvastoga liofiliziranoga koštanoga alogenoga transplantata (slika 1.b, c). Transplantat je dobiven od bedrenih glava živih darovatelja podvrgnutih artroplastičnoj operaciji. Prije liječenja pacijent je dao informirani pristanak za uključivanje u znanstvene publikacije.

Postupak augmentacije kosti obavljen je u općoj anesteziji na zahtjev pacijenta. Prije augmentacije kosti iz pacijentove krvi generirane su matrice plazme bogate trombocitima (PRP) i intravenski je, kao antibiotička profilaksa, primijenjeno 600 mg klindamicina (37). Dizajn reza koji je nedavno predstavila naša grupa pod nazivom "polustupni rez" primijenjen je za ulazak u mjesto defekta (35, 38). Umjesto položaja u sredini grebena, vodoravni rez postavljen je oko 20 mm bukalnije unutar pomične sluznice i samo je jedan vertikalni rasteretni rez dodan na distalnom kraju vodoravne linije reza. Nakon toga pažljivo je mobiliziran režanj vestibularne sluznice, a periost je odignut od maksilarne kosti tako da je keratinizirana sluznica iznad defekta ostala neoštećena (slika 2.a). Taj pristup olakšava pokrivanje transplantata velikog volumena bez napetosti i posljedično smanjuje rizik od dehiscencije rane i povezanih komplikacija.

Prije umetanja alogenoga koštanoga bloka, kortikalni sloj primateljskog mjesta više je puta perforiran dijamantnim svrdlom da bi se izazvalo krvarenje i poboljšala vaskularizacija transplantata (34). Blok je hidratiziran u serumu eksudata koji je dobiven tijekom proizvodnje PRP matrica (slika 2. b). Budući da je blok točno odgovarao geometriji defekta, nisu bile potrebne dodatne prilagodbe. Dodatno, zbog optimalnog prianjanja bloka na mjestu augmentacije za fiksaciju je bio dovoljan jedan titanijev 9-milimetarski vijak za osteosintezu promjera 1,5 mm (slika 2. c). Kako bi se spriječio pritisak koji čini glava vijka i popratna resorpcija transplantata, upuštena je glava vijka. Zbog izraženoga prekonturiranja koje je namjerno planirano, tanki sloj bloka vestibularno je izbrušen, a zatim prekriven resorptivnom kolagenskom membranom od svinjskoga perikarda (Jason® membrana, botiss biomaterials GmbH, Zossen, Njemačka) koji je fiksiran titanijevim čavlima. Završno je PRP matrica postavljena pre-

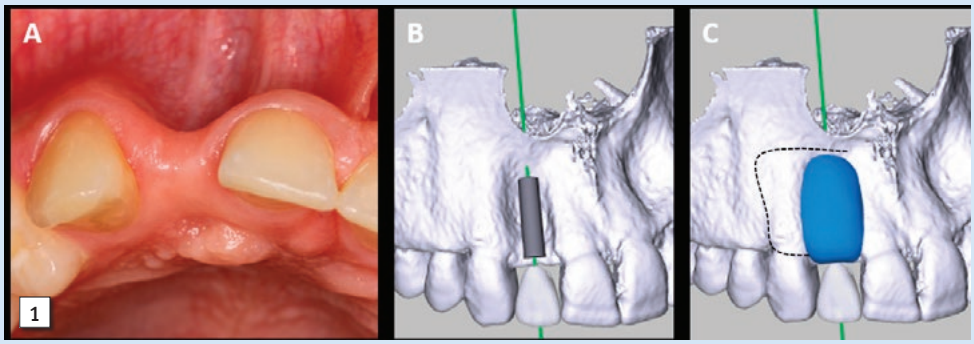


Figure 1 Initial defect situation and digital planning of the allogeneic bone block. Clinical demonstration of the area of missing tooth #7 (**A**). Digital planning of the implant and crown position (**B**) and the allogeneic bone block (**C**). Dashed black line indicated the incision line.

Slika 1. Inicijalni defekt i digitalno planiranje alogenoga koštanoga bloka; klinička demonstracija područja zuba koji nedostaje #7 **(A)** Digitalno planiranje položaja implantata i krunice (B) i alogenoga koštanoga bloka **(C).** Isprekidana crna linija označava liniju reza.

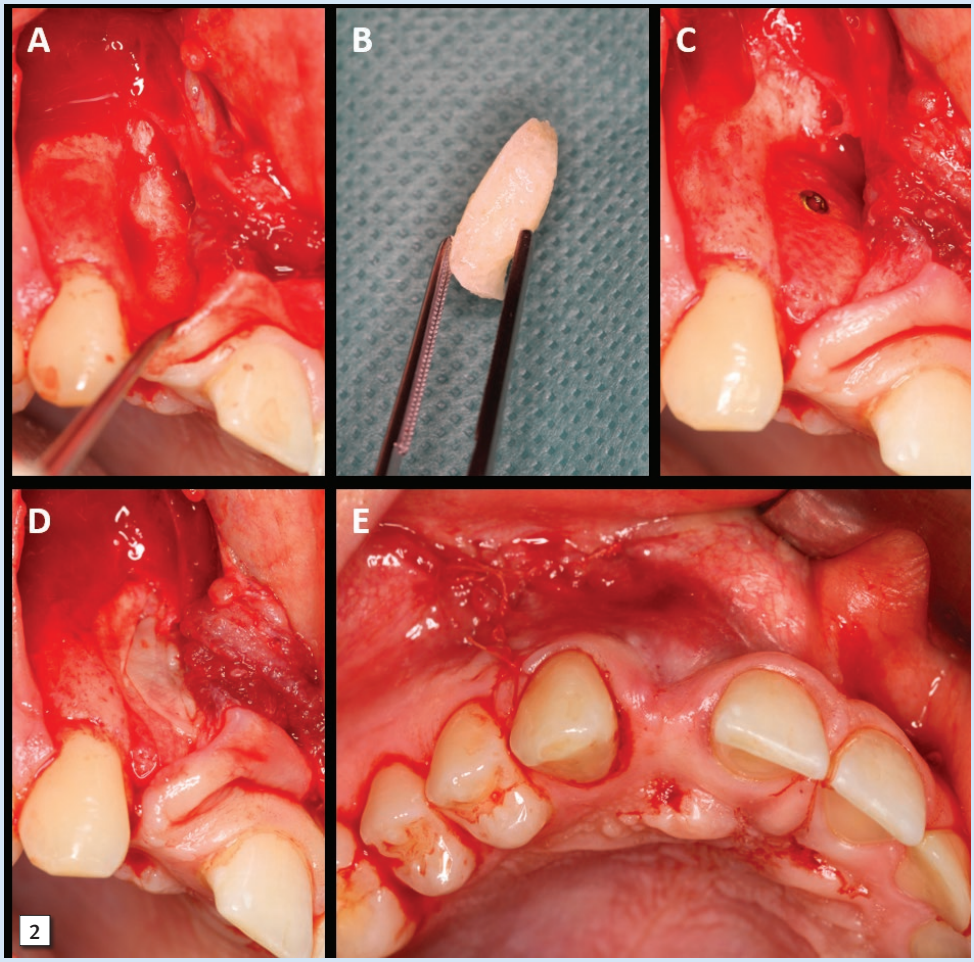


Figure 2 Conduct of the surgical intervention. Defect projection using the semi-pillar incision design (**A**). Sterile FDBA block hydrated with saline solution (**B**). Bone block mounted onto the alveolar ridge by a fixation screw (**C**). PRP matrix covering the bone graft (**D**). Saliva-tight and tension-free wound closure (**E**).

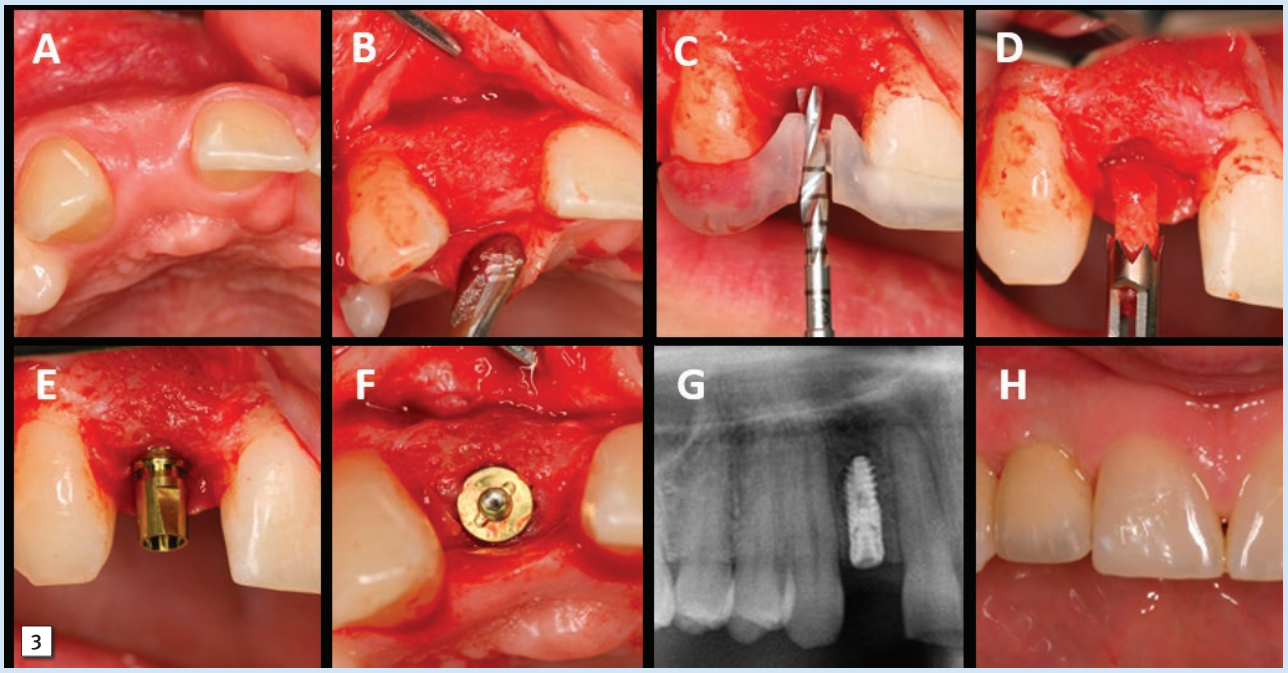
Slika 2. Provođenje kirurške intervencije. Projekcija defekta rezom dizajna polustupa **(A).** Sterilni blok FDBA hidratiziran fiziološkom otopinom **(B).** Blok kosti učvršćen na alveolarni greben s pomoću fiksacijskog vijka **(C).** PRP matrica koja prekriva koštani transplantat **(D).** Zatvaranje rane nepropusno i bez napetosti **(E).**

with a resorbable collagen membrane made of porcine pericardium (Jason® membrane, botiss biomaterials GmbH, Zossen, Germany), which was fixated with titanium pins. Finally, a PRP matrix was positioned over the grafting site with the intention of enhancing soft tissue healing (Figure 2 D). The flap was sutured saliva-tight and tension-free by single button pulley seams with absorbable 4.0 suture material (Figure 2 E).

Since the healing process was uneventful, the sutures were removed 14 days after surgery. Six months later (Figure 3 A), the re–entry was carried out under general anesthesia and oral antibiotic prophylaxis with 2000 mg amoxicillin was applied by the same surgeon. This time, a crestal incision was placed to access the augmented site (Figure 3 B). Following

ko mjesta presađivanja s namjerom da se poboljša cijeljenje mekoga tkiva (slika 2. d). Poklopac je zašiven nepropusno i bez napetosti pojedinačnim šavovima resorpcijskim koncem 4,0 (slika 2. e).

Budući da je proces cijeljenja protekao bez komplikacija, šavovi su uklonjeni 14 dana poslije operacije. Šest mjeseci kasnije (slika 3. a) ponovno otvaranje obavljeno je u općoj anesteziji i isti je kirurg primijenio oralnu antibiotičku profilaksu s 2000 mg amoksicilina. Ovaj put je učinjen rez na grebenu kako bi se pristupilo augmentiranom mjestu (slika 3. b). Nakon uklanjanja fiksacijskoga vijka stvorena je oznaka za bušenje s pomoću kirurške vodilice (slika 3. c) koja je također korištena kao pomoć pri uzimanju bioptata



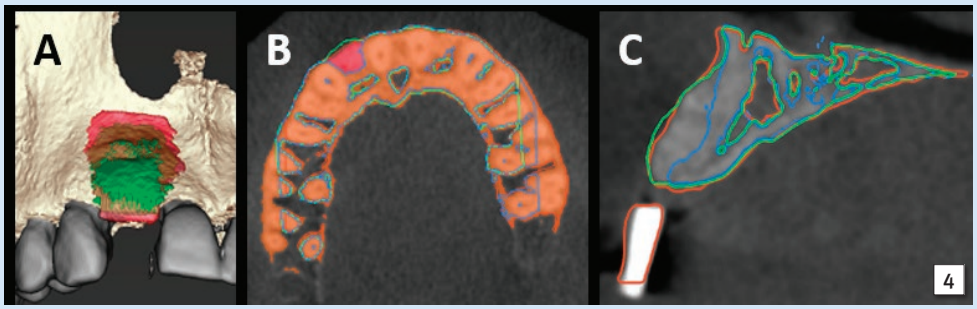


Figure 3 Re-entry and implantation procedure: Clinical situation after six months with view onto the alveolar ridge (**A**). Projection of the implantation site via a mid-crestal incision line (**B**). Drilling mark with a surgical drilling guide (**C**). Specimen extraction for histological and histomorphometrical analysis (**D**). Implantation (**E**) and final situation before suturing (**F**). Orthopantogram to control implant position (**G**). Final prosthetic restauration (**H**).

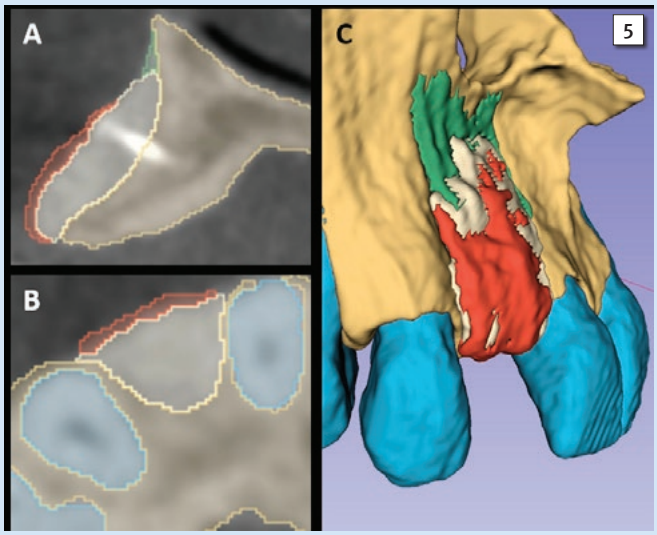
Slika 3. Ponovno otvaranje i postupak implantacije: klinička situacija nakon šest mjeseci s pogledom na alveolarni greben **(A).** Projekcija mjesta implantacije preko linije reza u sredini grebena **(B).** Oznaka za bušenje kirurškom vodilicom **(C).** Ekstrakcija uzorka za histološku i histomorfometrijsku analizu **(D).** Implantacija **(E)** i konačna situacija prije šivanja **(F).** Ortopantogram za kontrolu položaja implantata **(G).** Završna protetička opskrba **(H).**

Figure 4 Resorption analysis with coDiagnostiX®. Three-dimensional superimposition of the blocks from CBCT scans #2 (green) and #3 (A). Sagittal two-dimensional superimposition of all three CBCT scans #1 (blue line), #2 (green line) and #3 (red line). The red plane demonstrates the area of the block between the blue line (CBCT scan #1) and the red line (CBCT scan #3) (B). Axial two-dimensional superimposition of all three CBCT scans: #1 (blue line), #2 (green line), and #3 (red line) (C).

Slika 4. Analiza resorpcije s pomoću coDiagnostiX®-a. Trodimenzionalno superponiranje blokova iz CBCT skenova #2 (zeleno) i #3 **(A).** Sagitalno dvodimenzionalno preklapanje svih triju CBCT skenova #1 (plava linija), #2 (zelena linija) i #3 (crvena linija). Crvena ravnina prikazuje područje bloka između plave linije (CBCT sken #1) i crvene linije (CBCT sken #3) **(B).** Aksijalno dvodimenzionalno preklapanje svih triju CBCT skenova: #1 (plava linija), #2 (zelena linija) i #3 (crvena linija) **(C).**

the removal of the fixation screw, a drilling mark was created with the help of a surgical drilling guide (Figure 3 C), which was also used to aid harvesting a cylindrical bone core biopsy by means of a trephine drill (diameter: 3.0 mm, Fig. 3 D) and for guidance of the subsequent implant drills with a diameter of 3.4 mm and 3.8 mm. Finally, a dental implant (Xive, Dentsply Sirona, Bensheim, Deutschland) with a diameter of 3.8 mm and length of 11 mm was inserted in position #7 with a torque of 45 N·cm (Figure 3 E). The surgical site was closed by single button pulley sutures with an absorbable 6.0 suture material, which was removed one week later. A panoramic radiograph was recorded after implantation to examine the implant position (Figure 3 G), and again after three

cilindrične koštane jezgre (promjer 3,0 mm, slika 3. d) i za vođenje sljedećih svrdala za implantate promjera 3,4 mm i 3,8 mm. Konačno, dentalni implantat (Xive, Dentsply Sirona, Bensheim, Njemačka) promjera 3,8 mm i dužine 11 mm umetnut je na položaj #7 s momentom od 45 N·cm (slika 3. e). Kirurško mjesto zatvoreno je resorpcijskim koncem 6,0 koji je uklonjen tjedan dana poslije. Orotpantomogram je snimljen nakon implantacije da bi se provjerio položaj implantata (slika 3. g) te ponovno nakon tri mjeseca u trenutku otvaranja implantata, pri čemu je konačna protetička opskrba provedena četiri mjeseca poslije (slika 3. h). Tijekom cijeljenja implantata pacijent je dobio privremenu krunicu.



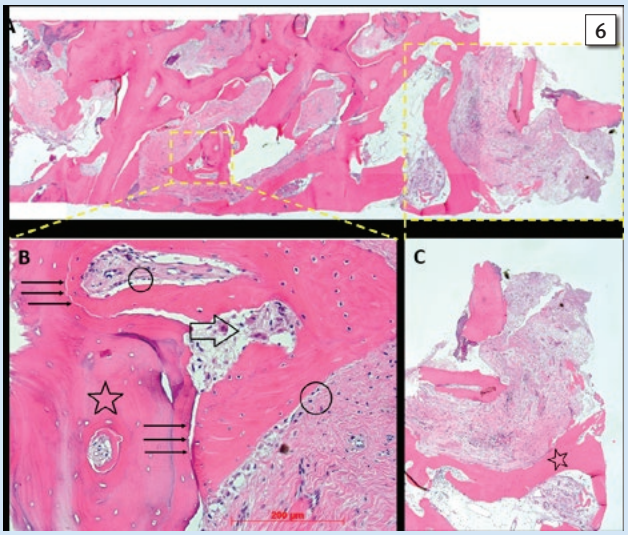


Figure 5 Resorption analysis with Slicer: Axial two-dimensional superimposition of all three CBCT scans, #1 (yellow line), #2 (red line) and #3 (beige line) (**A**). Sagittal two-dimensional superimposition of all three CBCT scans: #1 (yellow line), #2 (red line) and #3 (beige line) (**B**). Three-dimensional superimposition of the blocks from CBCT scan #2 (red) and #3 (green) (**C**).

Slika 5. Analiza resorpcije s pomoću Slicera: aksijalno dvodimenzionalno preklapanje svih triju CBCT skenova, #1 (žuta linija), #2 (crvena linija) i #3 (bež linija) **(A).** Sagitalno dvodimenzionalno preklapanje svih triju CBCT skenova: #1 (žuta linija), #2 (crvena linija) i #3 (bež linija) **(B).** Trodimenzionalno preklapanje blokova iz CBCT skenova #2 (crveno) i #3 (zeleno) **(C).**

Figure 6 Histological analysis. Overview of the histological section (left = apical, right = crestal) (**A**). Active remodeling and osteogenesis identifiable by newly formed bone trabecula (star), osteoblasts (circle), osteoclasts (open arrow) and transition zone between allogenic block and newly formed bone (arrows) (**B, C**).

Slika 6. Histološka analiza. Pregled histološkog presjeka (lijevo = apikalno, desno = krestalno) **(A).** Aktivno remodeliranje i osteogeneza koje se prepoznaju po novoformiranim koštanim trabekulama (zvjezdica), osteoblastima (krug), osteoklastima (otvorena strelica) i prijelaznoj zoni između alogenoga bloka i novoformirane kosti (strelice) **(B, C).**

months at the time of implant uncovering, whereby the final prosthetic restoration was inserted four months later (Figure 3 H). The patient received a provisional crown during the implant's healing course.

CBCT scans (KaVo 3D eXam, KaVo Dental, Biberach an der Riß, Germany; voxel size: 0.3 mm; field of view: 16.5 cm (diameter) x 13.50 cm (max. hight); tube voltage: 120 kV; tube current: 3–7 mA were recorded at three different time points; before the augmentation procedure, a baseline scan (#1) was conducted to assess the initial defect morphology for the virtual planning and customization of the bone block (Figure 3). A second scan (#2) was recorded immediately after bone augmentation to control for correct positioning of the bone block, and a third scan (#3) was done after six months to assess the vertical and horizontal hard tissue dimensions at the surgical site prior to implantation, and to examine the volume stability of the allogeneic bone block. For determination of the graft shrinkage during the healing course of six months, two different imaging tools for image matching were applied (coDiagnostiX®, Version 10.2.0.15659, Dental Wings Inc., Montreal, Canada; Slicer, open source software platform, https://www.slicer.org).

While alignment of scans in coDiagnostiX® was performed via manually selected reference points. The Slicer uses an intensity–based medical image registration algorithm (Elastix®, PerkLab, Queens University, Kingston, Canada) for this purpose. To calculate the block volumes, the coDiagnostiX® superimposed the aligned virtual models created from CBCT scans and measured the difference (Figure 4), whereas the Slicer automatically computed the entire volume

CBCT skenovi (KaVo 3D eXam, KaVo Dental, Biberach an der Riß, Njemačka; veličina voksela: 0,3 mm; vidno polje: 16,5 cm (promjer) x 13,50 cm (maks. visina); napon cijevi: 120 kV; struja cijevi: 3 – 7 mA snimljeni su u trima različitim vremenskom točkama; prije postupka augmentacije obavljeno je prvo skeniranje (#1) da bi se procijenila početna morfologija defekta za virtualno planiranje i prilagodbu koštanoga bloka (slika 3.). Drugo skeniranje (#2) provedeno je odmah nakon augmentacije kosti da bi se kontroliralo je li položaj koštanog bloka ispravan, a treće skeniranje (#3) učinjeno je nakon šest mjeseci da bi se procijenile vertikalne i horizontalne dimenzije tvrdoga tkiva na mjestu operacije prije implantacije i ispitala volumna stabilnost alogenoga koštanoga bloka. Za određivanje skupljanja transplantata tijekom šestoimjesečnoga cijeljenja primijenjena su dva različita slikovna alata za podudaranje slika (coDiagnostiX®, verzija 10.2.0.15659, Dental Wings Inc., Montreal, Kanada; Slicer, otvorena softverska platforma, https://www.slicer.org).

Dok je poravnavanje skenova u coDiagnostiX®-u obavljeno preko manualno odabranih referentnih točaka, Slicer u tu svrhu upotrebljava algoritam za registraciju medicinskih slika zasnovan na intenzitetu (Elastix®, PerkLab, Sveučilište Queens, Kingston, Kanada). Za izračunavanje volumena blokova coDiagnostiX® je superponirao usklađene virtualne modele stvorene iz CBCT-a i izmjerio razliku (slika 4.), a Slicer je automatski izračunao cijeli volumen virtualnih modela (cm^3) i oduzeo ih (slika 5.). Tom metodom softver je mogao izračunati početni volumen bloka V1 superponiranjem CBCT skenova #1 i #2 i konačni volumen bloka V2 superponiranjem skenova #1 i #3. Nakon toga izračunata je resorpcija tran-

of the virtual models (cm³) and subtracted them (Figure 5). With this method the software was able to calculate the initial block volume V1 by superimposing the #1 and #2 CBCT scan and the final block volume V2 by superimposing scans #1 and #3. Subsequently, the graft resorption was calculated by subtracting V2 from V1. To test the robustness of both imaging analyses and assess intra-and inter-investigator as well as inter-software variance, three investigators (OB, DP, KM) performed the measurements independently for three individual times. The results obtained by the individual investigators and software are shown below (Table. 1-3).

The mean volume of the allogeneic bone block immediately after insertion (V1) assessed by CoDiagnostiX®, and Slicer was 0.373 ± 0.00002 mL and 0.370± 0.00006 cm³ (Table 1), respectively, which decreased to 0.362 ± 0.00006 mL and 0.354 ± 0.00008 cm³ (Table 2) during the six months of healing (V2). The absolute volume loss assessed by the two imaging tools was 0.011 ± 0.00008 mL and 0.016 ± 0.00012 cm³, which corresponds to 3.00 ± 0.02% graft resorption assplantata oduzimanjem V2 od V1. Kako bi se testirala robusnost obiju metoda analize slike i procijenila unutar i međuistraživačka, te međusoftverska varijanca, tri istraživača (OB, DP, KM) neovisno su obavila mjerenja tri puta. Rezultati dobiveni od svakog istraživača i softvera prikazani su u nastavku (tablice 1. – 3.).

Prosječni volumen alogenoga koštanoga bloka neposredno nakon umetanja (V1) koji je procijenio CoDiagnostiX® i Slicer bio je 0,373 ± 0,00002 mL, odnosno 0,370 ± 0,00006 cm³ (tablica 1.) koji se smanjio na 0,362 ± 0,00006 mL i 0,354 ± 0,00008 cm³ (tablica 2.) tijekom šestomjesečnog cijeljenja (V2). Apsolutni gubitak volumena procijenjen dvama alatima za snimanje bio je 0,011 ± 0,00008 mL i 0,016 ± 0,00012 cm³, što odgovara resorpciji transplantata od 3,00 ± 0,02% procijenjenoj s pomoću CoDiagnostiX®-a i 4,33 ± 0,00012 cm³ procijenjenoga softverom Slicer (tablica 3.) .

Biopsijski uzorak fiksiran je u 4-postotnom neutralnom puferiranom formalinu tijekom 24 sata, dekalcificiran u 10-postotnoj puferiranoj EDTA-i na 37 °C tijekom 15 da-

Table 1 Volume of the allogeneic bone block (mL/cm³) after insertion. Numbers (#1-3) indicate repetitive measurements by the respective investigator.
Tablica 1. Volumen alogenoga koštanoga bloka (mL/cm³) nakon umetanja; brojevi (#1 – 3) označuju ponavljajuća mjerenja dotičnog istražitelja

coDiagnostiX					
Investigator • Istraživač	**#1**	**#2**	**#3**	**Mean • Srednja vrijednost**	**SD**
OB*	0.37342	0.37345	0.37341	0.37343	0.00001
DP*	0.37367	0.37362	0.37366	0.37365	0.00002
KM*	0.37325	0.37330	0.37323	0.37326	0.00003
				0.37345	**0.00002**
Slicer					
Investigator • Istraživač	**#1**	**#2**	**#3**	**Mean • Srednja vrijednost**	**SD**
OB*	0.37065	0.37051	0.37063	0.37060	0.00005
DP*	0.37031	0.37046	0.37044	0.37040	0.00006
KM*	0.36985	0.37001	0.36992	0.36993	0.00006
				0.37031	**0.00006**

*investigator initials • inicijali istraživača

Table 2 Volume of the allogeneic bone block (mL/cm³) following six months of healing. Numbers (#1-3) indicate repetitive measurements by the respective investigator.
Tablica 2. Volumen alogenoga koštanoga bloka (mL/cm³) nakon šestomjesečnog cijeljenja; brojevi (#1 – 3) označuju ponavljajuća mjerenja dotičnog istražitelja

coDiagnostiX					
Investigator • Istraživač	**#1**	**#2**	**#3**	**Mean • Srednja vrijednost**	**SD**
OB*	0.36239	0.36241	0.36252	0.36244	0.00005
DP*	0.36196	0.36205	0.36192	0.36198	0.00005
KM*	0.36218	0.36231	0.36244	0.36231	0.00009
				0.36224	**0.00006**
Slicer					
Investigator • Istraživač	**#1**	**#2**	**#3**	**Mean • Srednja vrijednost**	**SD**
OB*	0.35416	0.35427	0.35409	0.35417	0.00006
DP*	0.35401	0.35374	0.35411	0.35395	0.00014
KM*	0.35473	0.35462	0.35466	0.35467	0.00004
				0.35427	**0.00008**

Table 3 Volume loss of the bone block (mL/cm³ and %) during six month healing course. Numbers (#1-3) indicate repetitive measurements by the respective investigator.
Tablica 3. Gubitak volumena koštanoga bloka (ml/cm³ i %) tijekom šestomjesečnog cijeljenja; brojevi (#1 – 3) označuju ponavljajuća mjerenja dotičnog istražitelja

coDiagnostiX					
Investigator • Istraživač	**#1**	**#2**	**#3**	**Mean • Srednja vrijednost**	**SD**
OB*	0.01103 (2.95%)	0.01104 (2.96%)	0.01089 (2.92%)	0.01099 (2.94%)	0.00006 (0.02%)
DP*	0.01171 (3.13%)	0.01157 (3.10%)	0.01174 (3.14%)	0.01167 (3.12%)	0.00006 (0.02%)
KM*	0.01107 (2.97%)	0.01099 (2.94%)	0.01079 (2.89%)	0.01095 (2.93%)	0.00010 (0.03%)
				0.01120 (3.00%)	**0.00008 (0.02%)**
Slicer					
Investigator • Istraživač	**#1**	**#2**	**#3**	**Mean • Srednja vrijednost**	**SD**
OB*	0.01649 (4.45%)	0.01624 (4.38%)	0.01654 (4.46%)	0.01642 (4.43%)	0.00011 (0.03%)
DP*	0.01630 (4.40%)	0.01672 (4.51%)	0.01633 (4.41%)	0.01645 (4.44%)	0.00017 (0.04%)
KM*	0.01512 (4.09%)	0.01539 (4.16%)	0.01526 (4.13%)	0.01526 (4.12%)	0.00010 (0.03%)
				0.01604 (4.33%)	**0.00012 (0.03%)**

sessed by the CoDiagnostiX® and 4.33 ± 0.03% quantified with the Slicer software (Table 3).

The biopsy specimen was fixated in 4% neutral buffered formalin for 24 hours, decalcified in 10% Tris-buffered EDTA at 37°C for 15 days and then treated with solutions of ethanol in ascending concentration followed by a solution containing xylol. After embedding of the biopsies in paraffin, a microtone was used for cutting sections with a thickness of 3-5 µm. Slides were processed by means of hematoxylin-eosin stain for histological analysis. The histological examination included an analysis of the following parameters: graft integration, fibrosis, hemorrhage, necrosis, vascularization and the presence of lymphocytes, macrophages, osteoclasts, osteoblasts, and osteocytes. Randomly chosen light-microscopic images of defined size were captured from four sections of the specimen (original magnification x10, microscope: Axioskope 2, Carl Zeiss, Germany; camera: AxioCam MRC, Carl Zeiss). In each image, the areas of newly formed bone, residual bone grafting material, and soft tissue were analyzed and calculated as function of the total tissue using the AxioVision digital image processing software (Carl Zeiss). Area measurements were performed by two investigators and processed automatically by the software after defining the respective thresholds. Mean values of relative amounts were calculated.

The histological analysis revealed the following findings (Figure 6): The framework of the cancellous allogeneic bone block with trabeculae of varying thickness of lamellar bone with empty osteocyte lacunae and anchoring peri-trabecular ossification with varying width of woven bone, which exhibited occasional (crestal) remodeling processes into lamellar bone, were observed. Furthermore, transverse trabeculae of newly formed bone covered by tight connective tissue (propria) with loose infiltrates and allogenic bone fragments

na i zatim tretiran otopinama etanola u rastućoj koncentraciji nakon čega je slijedila otopina koja sadržava ksilol. Poslije ugradnje biopsije u parafin, mikrotom je korišten za rezanje slojeva debljine od 3 do 5 µm. Uzorci su obrađeni hematoksilin-eozinskim bojilom za histološku analizu. Histološki pregled uključivao je analizu sljedećih parametara: integraciju transplantata, fibrozu, krvarenje, nekrozu, vaskularizaciju i prisutnost limfocita, makrofaga, osteoklasta, osteoblasta i osteocita. Nasumično odabrane svjetlosno-mikroskopske slike definirane veličine snimljene su iz četiriju dijelova uzorka (izvorno povećanje x10, mikroskop: Axioskope 2, Carl Zeiss, Njemačka; kamera: AxioCam MRC, Carl Zeiss). Na svakoj snimci analizirana su područja novoformirane kosti, zaostaloga materijala za presađivanje kosti te mekoga tkiva i izračunata kao funkcija ukupnoga tkiva s pomoću softvera za digitalnu obradu slike AxioVision (Carl Zeiss). Mjerenja površine obavila su dva istraživača i automatski ih je obradio softver nakon definiranja odgovarajućih pragova. Izračunate su srednje vrijednosti relativnih iznosa.

Histološkom analizom utvrđeni su sljedeći nalazi (slika 6.): okvir spužvastoga alogenoga koštanoga bloka s trabekulama različite debljine lamelarne kosti s praznim osteocitnim lakunama i sidrenjem peritrabekularne osifikacije s promjenjivom širinom tkane kosti koji pokazuje mjestimično (krestalno) remodeliranje lamelarne kosti. Nadalje, poprečne trabekule novonastale kosti prekrivene čvrstim vezivnim tkivom (proprija) s labavim infiltratima i alogenim fragmentima kosti, zajedno s fragmentiranim višeslojnim skvamoznim epitelom djelomično prilijepljenim na ulomke kosti, identificirane su na mjestu grebena uzorka. Histomorfometrijska analiza pokazala je da je uzorak sastavljen od 41,5 %, 29,3 i 29,2 % novoformirane kosti, mekoga tkiva i rezidualnoga materijala za presađivanje.

along with fragmented multi–layered squamous epithelium, partly adherent to the bone fragments, were identifiable at the crestal site of the specimen. The histomorphometric analysis demonstrated that the specimen was composed of 41, 5%, 29, 3 and 29, 2% newly formed bone, soft tissue, and residual grafting material, respectively.

Discussion

The present case emphasizes the feasibility of successfully rehabilitating extensive bone defects in the maxillary esthetic zone by means of customized allogeneic bone blocks. The assessment of the volumetric changes of the block during healing was easily conductible with both imaging tools. Although the initial graft volume calculated via Slicer was lower and the absolute resorption was increased as compared to the respective values obtained via coDiagnostiX®, the calculated resorption of 3.00 ± 0.02% (coDiagnostiX®) and 4.33 ± 0.03% (Slicer) was within a comparable range. However, a bigger cohort with more blocks requires assessment via this method in order to precisely evaluate a potential inter-software measuring bias. The mean resorption of 3.67 ± 0.03%, which we found during the six months, is slightly below compared with those reported for manually adapted cancellous FDBA blocks by another study (36). A slightly lower resorption observed in this case may have resulted from the optimal fit of the block which enhanced the contact between the graft and the host bone, but also from the defect geometry, which provided a cavity for the block to be positioned in (20).

Both imaging tools indicated that the volume loss occurred on the labial side, whereas the block remained stable in vertical dimensions. While the defect's geometry supported the vertical stability of the graft, leaving the periosteum on the crestal site undamaged, the application of the semipillar incision may have further reduced vertical resorption (40). Although the evidence on the beneficial effects of barrier membranes in counteracting graft resorption remains elusive, a previous randomized controlled trial reported significantly lower bone resorption for cortico-cancellous allogeneic bone granules covered by a collagen membrane as compared to augmentation sites left uncovered (41-48). Consequently, the application of a barrier membrane is likely to have contributed to the low graft resorption we observed. The greatest tension, and hence pressure is located on the labial site of the graft, which also holds the greatest distance from the host bone, so that especially this area is at risk to be subjected to resorption before remodeling is completed (41,42).

One concern associated with allogeneic bone blocks is the occurrence of complications including wound dehiscences and subsequent graft exposure. This primarily affects vertical bone augmentations since a previous study carried out with CAD/CAM manufactured allogeneic bone blocks reported widely unfavorable results (43). However, the risk of exposure is not specifically associated with the allogeneic bone graft, but rather with improper soft-tissue management. In a study analyzing complications in 137 cancellous allogeneic bone grafts, Chaushu and others have found high frequency of complications, which was not associated with

Rasprava

Ovaj slučaj ističe izvedivost uspješne rehabilitacije opsežnih koštanih defekata u maksilarnoj estetskoj zoni s pomoću individualiziranih alogenih koštanih blokova. Procjena volumetrijskih promjena bloka tijekom cijeljenja jednostavno se provodila s oba alata za snimanje. Iako je početni volumen transplantata izračunat s pomoću Slicera bio manji, a apsolutna resorpcija povećana u usporedbi s odgovarajućim vrijednostima dobivenim coDiagnostiX®-om, izračunata resorpcija od 3,00 ± 0,02 % (coDiagnostiX®) i 4,33 ± 0,03 % (Slicer) bila je unutar usporedivog raspona. Međutim, veća skupina s više blokova zahtijeva procjenu ovom metodom kako bi se precizno procijenila potencijalna međusoftverska mjerna pristranost. Prosječna resorpcija od 3,67 ± 0,03 %, koju smo pronašli tijekom šest mjeseci, nešto je niža u usporedbi s onom iz drugog istraživanja stručno prilagođenim spužvastim blokovima FDBA-e (36). Nešto niža resorpcija uočena u ovom slučaju mogla je biti rezultat optimalnog pristajanja bloka koji je poboljšao kontakt između transplantata i kosti domaćina, ali i geometrije defekta koja je stvorila šupljinu u koju se blok postavlja (20).

Oba alata za snimanje pokazala su da se gubitak volumena dogodio na labijalnoj strani, au vertikalnim dimenzijama blok je ostao stabilan. Dok je geometrija defekta podržavala vertikalnu stabilnost transplantata, ostavljajući periost na mjestu grebena neoštećenim, primjena incizije polustupa može dodatno smanjiti vertikalnu resorpciju (40). Iako su dokazi o korisnim učincima barijernih membrana u suzbijanju resorpcije transplantata i dalje nedostupni, u prethodnom randomiziranom kontroliranom istraživanju ističe se značajno manja resorpcija kosti za kortikospongiozne alogene koštane granule prekrivene kolagenskom membranom u usporedbi s mjestima augmentacije koja su ostala nepokrivena (41 – 48). Posljedično, primjena barijerne membrane vjerojatno je pridonijela maloj resorpciji transplantata koju smo primijetili. Najveća napetost, a time i pritisak, nalazi se na labijalnom mjestu transplantata koje ujedno drži i najveću udaljenost od kosti domaćina tako da je to područje posebno u opasnosti da bude izloženo resorpciji prije dovršetka remodeliranja (41, 42) .

Problem povezan s alogenim koštanim blokovima jest pojava komplikacija, uključujući dehiscencije rane i naknadno izlaganje transplantata. To najčešće utječe na vertikalnu augmentaciju kosti jer su autori prethodnog istraživanja provedenog s alogenim koštanim blokovima proizvedenima CAD/CAM-om izvijestili o vrlo nepovoljnim rezultatima (43). Međutim, rizik od izlaganja nije posebno povezan s alogenim koštanim transplantatom, nego s nepravilnim upravljanjem mekim tkivima. U istraživanju u kojem su analizirane komplikacije u 137 spongioznih alogenih koštanih transplantata,

the bone graft itself but rather with the soft tissue situation and management (46). Additionally, the manual adjustment of bone blocks displays a certain potential for graft contamination from oral fluids, surgical instruments, the surgeon's gloves and other external factors (33). The combination of CAD/CAM milled bone blocks with the semi-pillar incision in the flexible mucosa lowers both the risk of graft contamination and wound dehiscence while also reducing the surgical time by avoiding bone harvesting and adaptation.

The histological analysis demonstrated the active remodeling and integration process of the allogeneic bone block, which was supported by the histomorphometric evaluation. We found an advanced osteogenesis within the allogenic bone matrix, whereby crestal mucosal remnants on the basal edge were accompanied by moderate signs of immunologic cell infiltration, and hence inflammation. As a previous study demonstrated that graft turnover and new bone formation associated with cancellous allogeneic bone blocks in the anterior maxilla of patients aged 39 and below was increased as compared to older patients, the young age of the included patient may have contributed to our favorable results (47, 48). Additionally, with a mean of 38.6% of new bone found in specimens harvested from the anterior maxilla, the results obtained by the authors of that study were similar to ours.

Conclusions

Overall, our preliminary results demonstrate low resorption with advanced graft turnover and hence, the successful restoration of an extensive maxillary bone defect with an allogeneic bone block, which demonstrates the advantages of the customization process and emphasizes the feasibility of reliable volume quantification and assessment of bone resorption via the two applied imaging tools. Nevertheless, the validity of these findings is limited, as only one subject was included in the present report. Hence, further controlled studies with a much larger sample size are required to corroborate these promising initial results.

Conflict of interest

Phil Donkiewicz is currently employed as a Key Account Manager for the Straumann Group and simultaneously enrolled as a doctoral student at the Witten/Herdecke University. We received no financial support and no free materials from Straumann or any other company for this study. All surgical procedures were conducted within the regular practice plan. We confirm that the associations with the Straumann group had no impact on the here demonstrated results.

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Chaushu i suradnici pronašli su visoku učestalost komplikacija koje nisu bile povezane sa samim koštanim transplantatom, nego sa stanjem mekoga tkiva (46). Dodatno, manualno prilagođavanje koštanih blokova pokazuje određeni potencijal za kontaminaciju transplantata oralnim tekućinama, kirurškim instrumentima, kirurškim rukavicama i drugim vanjskim čimbenicima (33). Kombinacija koštanih blokova obrađenih CAD/CAM-om s polustupnim rezom u fleksibilnoj sluznici smanjuje rizik od kontaminacije transplantata i dehiscencije rane, a također skraćuje kirurško vrijeme izbjegavanjem uzimanja i adaptacije kosti.

Histološka analiza pokazala je aktivan proces remodeliranja i integracije alogenoga koštanog bloka, što je potkrijepljeno histomorfometrijskom analizom. Pronašli smo napredovalu osteogenezu unutar alogene koštane matrice, pri čemu su ostatci krestalne sluznice na bazalnom rubu bili praćeni umjerenim znakovima infiltracije imunosnim stanicama, a time i upale. Kako je istaknuto u prethodnom istraživanju, pregradnja transplantata i stvaranje nove kosti povezano sa spongioznim alogenim koštanim blokovima u prednjoj maksili pacijenata u dobi od 39 i manje godina povećanje u usporedbi sa starijim pacijentima, pa je mlada dob uključenog pacijenta mogla pridonijeti našim povoljnim rezultatima (47, 48). Osim toga, s prosjekom od 38,6 % nove kosti pronađene u uzorcima uzetima iz prednje maksile, rezultati koje su dobili autori toga istraživanja bili su slični našima.

Zaključci

Sveukupno naši preliminarni rezultati pokazuju malu resorpciju transplantata, a time i uspješnu rekonstrukciju opsežnoga defekta maksilarne kosti alogenim koštanim blokom. To pokazuje prednosti procesa prilagodbe transplantata i ističe izvedivost pouzdane kvantifikacije volumena i procjene resorpcije kosti dvama alatima za analizu slika. Ipak, valjanost tih nalaza ograničena je zato što je samo jedan subjekt uključen u ovaj prikaz. Zato su potrebna daljnja kontrolirana istraživanja s mnogo većim uzorkom kako bi se potvrdili ovi obećavajući početni rezultati.

Sukob interesa

Phil Donkiewicz trenutačno je zaposlen kao Key Account Manager za Straumann Grupu i istodobno je upisan kao doktorand na Sveučilištu Witten/Herdecke. Za ovo istraživanje nismo dobili nikakvu financijsku potporu ni besplatne materijale bilo od Straumanna bilo od koje druge tvrtke. Svi kirurški zahvati obavljeni su u sklopu redovitoga plana liječenja. Potvrđujemo da povezanost sa Straumannovom grupom nije utjecala na ovdje prikazane rezultate.

Zahvale

Zahvaljujemo Branku Trajkovskom i Bálintu Molná na pomoći tijekom pisanja i uređivanja teksta. Nadalje, želimo zahvaliti Goranu Nikoloskom na virtualnom dizajnu alogenoga koštanog bloka.

Authors' contributions: **O. B.** – Methodology, Investigation, Resources, Writing - Original Draft, Writing - Review & Editing, Visualization, Supervision, Project administration; **P. D.** – Methodology, Writing - Original Draft, Writing - Review & Editing, Visualization; **D. P.** – Methodology, Writing - Original Draft, Data Analysis, Writing - Review & Editing, Visualization; **W. G.** – Histologic and histomorphometric evaluation; **P. W.** – Supervision, Project administration.

Doprinosi autora: **O. B.** – metodologija, istraživanje, resursi, pisanje izvornoga nacrta, pisanje pregleda i uređivanje, vizualizacija, nadzor, administracija projekta; **P. D.** – metodologija, pisanje izvornoga nacrta, pisanje pregleda i uređivanje, vizualizacija; **D. P.** – metodologija, pisanje izvornoga nacrta, pisanje pregleda i uređivanje, vizualizacija; **W. G.** – histološka i histomorfometrijska procjena; **P. W.** – nadzor, administracija projekta.

Sažetak

Svrha istraživanja: Svrha ovog prikaza slučaja bila je predstaviti metodu za procjenu volumetrijskih promjena koštanih blokova tijekom cijeljenja i pokazati njezinu izvedivost analizom resorpcije prethodno oblikovanoga alogenoga koštanoga bloka koji se upotrebljava za rekonstrukciju složenoga maksilarnog defekta. **Materijal imetoda:** CBCT snimke 19-godišnjeg muškarca liječenoga alogenim koštanim blokom učinjene su prije operacije, poslije toga zahvata i šest mjeseci nakon cijeljenja. Skupljanje transplantata procijenjeno je s pomoću dvaju alata za podudaranje slika, odnosno alatima coDiagnostiX® i Slicer. Biopsijski uzorak uzet je duž kanala implantata tijekom implantacije. **Rezultati:** Koštani defekt uspješno je rekonstruiran, a nakon ponovnog otvaranja pronađeno je napredno remodeliranje transplantata što je potvrđeno histomorfometrijskom i histološkom analizom. Početni volumeni transplantata određeni alatima coDiagnostiX® i Slicer bili su 0,373 mL odnosno 0,370 mL, a resorpcija transplantata poslije šest mjeseci cijeljenja iznosila je 0,011 mL (3,00%) i 0,016 ml (4,33%). **Zaključci:** Izbjegavanje uzimanja kosti i smanjenje invazivnosti važan su problem u dentoalveolarnim rekonstrukcijama. Najoprije nego što se materijali za presađivanje mogu smatrati sigurnom alternativom, ključno je razumjeti njihovu kliničku učinkovitost, posebno stabilnost na resorpciju. Ovaj prikaz slučaja pokazuje ograničenu resorpciju alogenoga koštanoga bloka i dodatno ističe izvedivost određivanja resorpcije kosti ovdje predstavljenom metodom. Kako naše istraživanje obuhvaća samo jedan slučaj, rezultate treba pozorno razmotriti i potkrijepiti daljnjim istraživanjima.

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MeSH terms: transplantacija kosti; alogeni transplantati; materijali za nadomještanje kosti
Autorske ključne riječi: alogeni koštani transplantat; koštani blok, resorpcija transplantata, biomaterijali, presađivanje kosti, liofilizirani koštani alogeni transplantat

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