CLINICAL STUDY

Comparison of Two Techniques for Lateral Ridge Augmentation in Mandible With Ramus Block Graft

AQ2 *Horia Mihail Barbu, DMD, PhD,[*] Claudia Florina Andreescu, DMD, PhD,[†] Adi Lorean, DMD,[‡] Roni Kolerman, DMD,[§] Liliana Moraru, O&MFS, PhD,[||] Carmen Mortellaro, MD, DDS,[¶] and Eitan Mijiritsky, DMD[#]*

Abstract: The purpose of this manuscript was to assess mandibular ramus block grafts used for augmentation of mandibular posterior segments, followed by subsequent implant placement. Twenty-four human subjects in need of lateral ridge mandibular augmentation were included in the current patient series. Inclusion criteria: recipient site had at least 10-mm residual height, but less than 4.3-mm bucco-lingual dimension. Autogenous bone blocks were harvested from the mandibular ramus. In the first group ramus block was used in association with platelet-rich fibrin and in the second in association with pericardium membrane. Implant surgery was performed 4 months after bone graft surgery when a total number of 44 implants were placed. Abutments were placed 4 months after implant surgery followed by final restoration. Ramus bone graft was successful in 100% patients for the first group and in 91.67% patients for the second group. Measurement on cone beam computed tomography revealed an average of 5.35 mm of lateral ridge augmentation for group 1 and 5.099 mm for group 2, achieved 4 months after surgery. All implants placed received fixed prosthetic restorations and are in use. Ramus block grafts can be used to allow optimal implant placement, with favor long-term success. Lateral ridge augmentation using mandibular ramus bone graft in association with platelet-rich fibrin is a more predictable and successful technique.

Key Words: Autogenous bone block resorption, bone augmentation, dental implant, mandibular ramus

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AQ3 From the *Oral Implantology Department.; †Department of Oral Rehabilitation, Faculty of Dental Medicine, University Titu Maiorescu, Bucharest, Romania; ‡Department of Oral and Maxillofacial Surgery; §Department of Periodontology, School of Dental Medicine, Tel-Aviv University, Tel-Aviv, Israel; ||Central Military Emergency Hospital Dr. Carol Davila, Bucharest, Romania; ¶Department of Health Sciences "A. Avogadro", University of Eastern Piedmont, Novara, Italy; and #Department of Oral Rehabilitation, School of Dental Medicine, Tel Aviv University, Tel Aviv, Israel.

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AQ4 Address correspondence and reprint requests to Eitan Mijiritsky DMD, Department of Oral Rehabilitation, School of Dental Medicine, Tel Aviv University, Tel Aviv, Israel; E-mail: mijiritsky@bezeqint.net

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Alveolar ridge resorption after tooth loss is a common phenomenon. After tooth extraction, the alveolar ridge decreases rapidly in width and height. Frequently in clinical practice, tooth loss does not coincide with dental implant replacement. Often there is an interval of months or years between tooth extraction and implant placement. As a result, to perform an optimal implant placement and to improve the long-term prognosis, it is required alveolar ridge augmentation to increase bone volume previous to implant placement.

While maxillary sinus augmentation procedure has been well documented, and the long-term clinical success/survival, alveolar AQ5 ridge augmentation techniques do not have detailed documentation or long-term follow-up studies.[1]

In narrow alveolar ridges, different grafting techniques may be used, but autogenous bone grafting offers sufficient long-term results for ridge reconstruction because in Romania as in other countries from Europe in this moment only xenografts and alloplasts are authorized by Ministry of Health.

The purpose of this article was radiological assessment from 2 up to 6 years of mandibular ramus block grafts used for augmentation of mandibular posterior segments, followed by subsequent implant placement.

METHODS

Twenty-four patients in need of lateral ridge augmentation were included. Sites sampled were in the mandibular posterior segments left or right. All patients underwent thorough clinical and paraclinical evaluation (imaging and blood tests) and provided written informed consent. Patient data was deidentified before it was provided to us for research. Standard informed consent that patients are signing before undergoing implant surgeries contains approval for their information to be stored in the institution database and used for further investigation. Patients are also signing an additional informed consent for future research. The Medical Ethics Committee of Titu Maiorescu University approved this study, including the consent protocols.

The patients were divided into 2 groups: group 1 (12 patients) where autogenous bone blocks were covered by autogenous particulate bone and PRF membrane and group 2 (12 patients) where autogenous bone blocks were covered by composite graft (autogenous particulate bone chips mixed with xenograft particulate bone) and pericardium membrane.

The bone grafting procedures were performed between April 2009 and November 2013.

A pre- and postoperative cone beam computed tomography (CBCT) scan was taken. The recipient site was required to have at least 10-mm residual height, but less than 4.3-mm bucco-lingual dimensions. The study population consisted of 11 men and 13 women with an age range of 24 to 71 years (Table 1). Patients with a history of smoking, uncontrolled systemic disease, or active periodontal disease were excluded. Autogenous bone blocks were harvested from the mandibular ramus distal of the last tooth as cortico-cancellous block.

TABLE 1. Age Distribution of Study Group

	Study Group		
Age Segment	**Male**	**Female**	**Total**
20–29 years old	3 (12.50%)	0 (0.00%)	3 (12.50%)
30–39 years old	2 (8.33%)	3 (12.50%)	5 (20.83%)
40–49 years old	1 (4.17%)	5 (20.83%)	6 (25.00%)
50–59 years old	5 (20.83%)	4 (16.67%)	9 (37.50%)
Over 60 years old	0 (0.00%)	1 (4.17%)	1 (4.17%)
Total	11 (45.83%)	13 (54.17%)	24 (100%)

Premedication with antibiotics (Amoxicilin or Clindamycin) and steroid (Dexamethasone) was started 1 day prior to surgery. Local anesthesia (Articaine 1:100,000 Epinephrine) was followed by exposure of the recipient site with a full thickness flap utilizing midcrestal incisions combined with 2 vertical incisions. Anterior vertical incision was done at least 2 teeth distant from the ridge deficiency or in the case of edentulous areas maintaining a distance of 7 mm mesial from expected graft area borders. Posterior vertical incision was done at the level of the ramus, distal to the last tooth to offer both access to the donor site and additional protection against postoperative exposure of graft. Selective cortical perforation of the recipient bed was made with small round bur which opened sites to possible marrow cell contribution and increased vascularization (Fig. 1A). A horizontal incision was made on the inner aspect of flap as low as its possible to the base of the flap through the periosteum into the mucosal compartment to allow tension-free closure after later expansion of the site and to reduce bleeding at suture time.

The donor template was fabricated from sterile suture wrapping and the bone block was cut with a piezosurgery cutting tool (PiezoART Surgical Unit, Dowell, IL) followed by elevation with a chisel (Aesculap; B. Braun Melsungen AG, Melsungen, Germany) (Fig. 1B). Fixation screw holes were pretapped with 1.8-mm drill, after block removal from donor site, to be slightly larger than the surgical screw diameter of 1.6 mm, to obtain a lag effect. Autogenous cortico-cancellous bone chips were then harvested using a special drill (ACM, Neobiotech, Korea) from the surrounding area of the donor site as well as from the mandible body (Fig. 2A). AQ6

Group 1

After modeling both the donor block and the recipient site, the block and autogenous chips used as "filler" material were soaked in the residual venous blood fluids prior to placement. Fixation was done with 2 screws to secure the block and then open areas were filled with particles from donor site (Fig. 2B). Six to 8 tubes were collected from peripheral venous blood and centrifuged to separate platelet-rich fibrin (PRF) and supernatant fluids, which contained growth factors[2] while the procedure was in process. All graft materials were soaked in the fluids resulted from PRF prior to placement in the recipient site. The fixed block was then covered with PRF membranes.

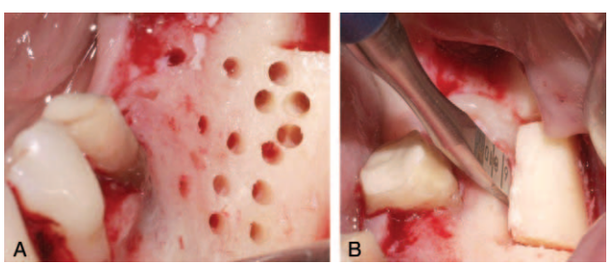

FIGURE 1. (A) Selective cortical perforation of the recipient site made with small round bur. (B) Elevation of the bone block with a chisel.

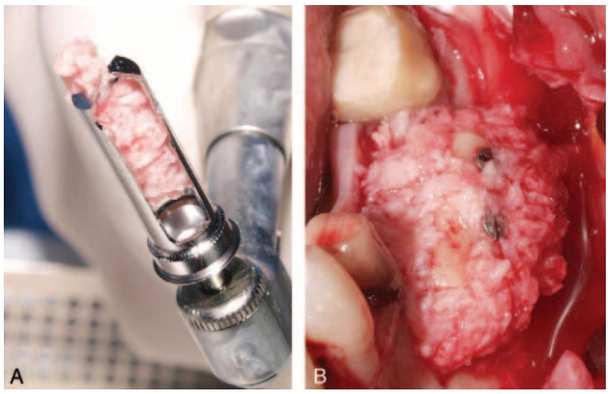

FIGURE 2. (A) Autogenous cortico-cancellous bone chips are harvested from the surrounding area of the donor site. (B) Group 1, the gaps between bone block and the mandible are filled with autogenous bone chips.

Group 2

The autogenous chips were mixed with large xenograft particles (1–2 mm size) from bovine material (Bio-oss, Geistlich, Switzerland) in a ratio of 25% xenograft and 75% autogenous chips. The fixed block and the composite graft were then covered with a low rate resorption pericardium membrane (CopiOs Pericardium, Zimmer Dental Inc, USA) with care taken to maintain slight separation from the adjacent tooth surfaces. (Fig. 3A and B) AQ7

Sutures were done in 2 layers with 4-0 and 6-0 polypropylene. Postoperative instructions included no prosthesis, no mouthwash with chlorhexidine, and no nonsteroidal anti-inflammatory drugs (NSAIDs). For postoperative pain was prescribed acetaminophen because has no influence on bone healing.[3] Antibiotics were continued for 6 days. AQ8

Four months postoperative was allowed prior to postoperative CBCT scan to benefit of bone volume after bone graft (Fig. 4A and B).

Implant osteotomy was accomplished after screws removal in second surgery stage for both groups. A number of 1 to 3 implants (TSV, Zimmer Dental Inc) were placed according to length of recipient size. Implant dimensions varied from 3.7 to 4.7 mm diameter and 10 to 13 mm in length (Table 2). At this stage, in

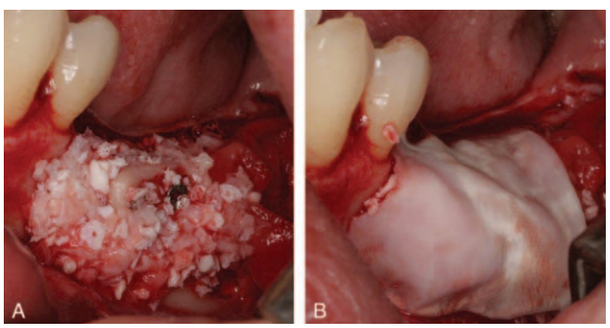

FIGURE 3. (A) Group 2, the bone block is covered and the gaps are filled with composite graft. (B) Group 2, a low rate resorption pericardium membrane is sealing the block and particulated bone.

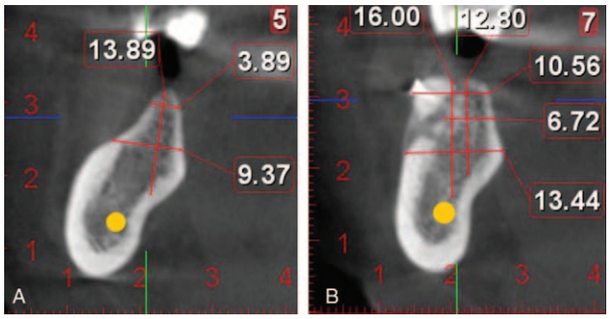

FIGURE 4. (A) Initial CT. (B) Control CT 4 month post-op. CT, computed tomography.

TABLE 2. Dimension of Implants Used in This Study (Zimmer Dental Inc)

Diameter (mm)	Length (mm)	Number of Implants
3.7	10	7
3.7	11	8
3.7	13	1
4.1	10	9
4.1	11	12
4.1	13	2
4.7	10	3
4.7	11	4
4.7	13	1
		47

group 1, we can observe that some of the bone blocks are partially resorbed (Fig. 5A). After implant osteotomy, xenograft particles are placed over the bone block (Fig. 5B and C). After osseointegration, the xenograft particles will prevent future resorption of the bone block. Everything is covered by pericardium membrane (Fig. 5D).

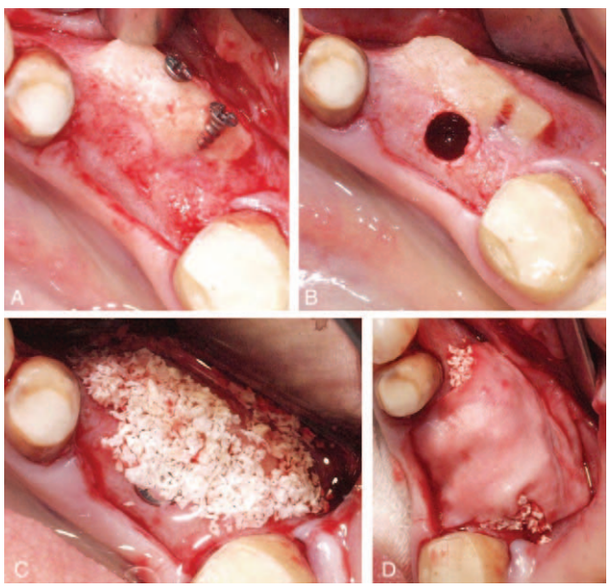

FIGURE 5. (A) Group 1, clinical aspect of the bone block 4 months post-op shows partial resorption of the bone block. (B) Group 1, osteotomy is made for implant placement. (C) Group 1, xenograft particles are covering the entire bone block. (D) Group 1, pericardium membrane is placed over the particulate bone.

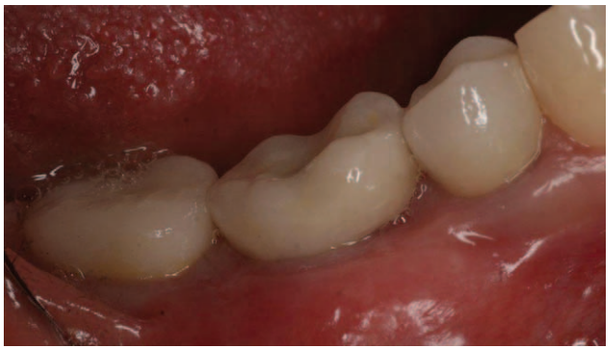

FIGURE 6. Final restoration.

Healing abutments were placed 3 months after implant surgery followed by final restoration according to the standards of care for implant prosthodontics (Fig. 6).

RESULTS

Clinical and radiological findings are summarized in Tables 3 to 5.

Clinical findings revealed good evolution after first surgery. Exposure of bone graft during healing was noticed in one of 24 subjects, from group 2, and appeared 2 weeks after surgery. One week later exposed part of bone graft revealed sign of necrosis (discolorations and soft consistency) and was removed (Fig. 7).

No complications arise at donor site, except in 3 subjects (2 from group 1 and 1 from group 2), who reported persistent pain after surgery. Symptoms were solved 3 weeks postoperatively.

Ramus bone graft was successful in 23 out of 24 patients (95.83%), 100% from group 1 and 91.67% for group 2.

Second surgery, for implant placement was performed 4 months after bone grafting surgery. During implant surgery all bone grafts appear to be fixed at the recipient site. The particulate bone graft, a mixture of autogenous bone marrow and bovine material, appeared well incorporated at the recipient site. During the placement of implant was achieved primary stability for all implants.

All implant are restored with fixed prosthetic restoration, crowns and bridges, all in used for at least 3 months. The average follow-up for prosthetic work is 19.78 months. No prosthetic complication occurred during follow-up.

Measurement on CBCT revealed an average of 5.23 mm of lateral ridge augmentation (5.35 for group 1 and 5.099 for group 2), achieved 4 months after surgery.

DISCUSSION

In the past, treatment planning for implant dentistry was mainly driven by the existing bone volume in the edentulous sites. Esthetics demands[4] and complications associated with implant dentistry[5] lead to development a treatment plan based on optimal placement of implants according to prosthesis design.[6]

A number of treatment options have been described for bone augmentation of deficient edentulous ridges before implant placement. These include: guided bone regeneration with or without bone grafting, ridge splitting, distraction osteogenesis, orthodontic tooth movement through a deficient ridge and grafting with bone blocks harvested intraorally, extraorally, or from allogeneic sources.

There is a high level of evidence to support that survival rates of implants placed in augmented bone are comparable to rates of implants placed in pristine bone.[7,8]

While different xenografts, allografts, and alloplastic bone grafts have been proposed, studied and used for alveolar ridge

TABLE 3. Demonstration of Patient Data and Surgical Procedures Inclusive Survival Rates of the Placed Implants for Group 1

Patient	Age	Sex	Recipient Site*	Initial Width (mm)	Complication at Donor Site	Complication at Recipient Site	Final Width (mm) After 5 Mo	Lateral Ridge Augmentation Achieved (mm)	Number of Implants	No of Fixation Screws	Follow-Up (Mo)†
1.	51	F	19	4.01	None	None	9.24	5.23	2	2	36
2.	49	F	30	3.85	None	None	9.03	5.18	2	2	35
3.	41	F	19	3.97	None	None	9.32	5.35	1	2	28
4.	33	M	19–20	4.22	Pain	None	10.17	5.95	3	2	52
5.	54	M	19	3.12	None	None	9.21	6.09	1	2	57
6.	27	M	30	4.15	None	None	10.03	5.88	2	2	27
7.	50	M	30	3.24	None	None	8.53	5.29	1	2	11
8.	29	M	19–20	3.53	None	None	8.33	4.8	2	2	10
9.	54	F	29–30	2.95	None	None	8.02	5.07	3	2	8
10.	42	M	30	3.11	None	None	7.94	4.83	2	4	2
11.	24	M	30	4.21	None	None	10.13	5.92	1	2	2
12.	57	F	19–20	2.69	Pain	none	7.31	4.62	3	2	20
Average				3.5875			8.9383	5.35			24

*US tooth number used.
†After delivery of prosthetic rehabilitation.

augmentation, the gold standard of bone grafting materials is autografts.[9] Brånemark[10] originally described autologous bone grafts used with dental implants, and now reconstruction with bone grafts is a well-accepted procedure in oral and maxillofacial rehabilitations.[11–14]

Advantages of autograft are: proximity of donor and recipient sites, convenient surgical access, and decreased costs.

Autogenous bone blocks represent a very good option for bone augmentation, because in Romania at this moment only xenografts and alloplasts are authorized by Romanian Ministry of Health. Mandibular ramus provides cortical bone characterized by a shorter healing period, maintenance of osseous density, and low rate of complications.[15] Also, mandibular cortical grafts have the highest concentrations of bone morphogenetic proteins, which are potent growth factors with ability to produce bone[16] and it is possible to reuse same site for a second bone harvesting.[17]

The main disadvantage of autograft is the morbidity of a second surgical site manifested as: immediate postoperative pain and edema, infections, haematomas, and neurosensory deficits. Mandibular ramus bone harvesting for reconstructing local alveolar defects is a well-accepted procedure with low objective and subjective morbidity.[18] Postoperative morbidity ranged from 0% to 5% for mandibular ramus[19] or 9.8% manifested as pain during chewing and bleeding.[20] A recent study[21] reported 1.58% primary healing complications at donor sites, most in smokers. In this study 3 (12.5%) subjects reported persistent pain at donor site. This complication is reversible and had no impact on patient's life. No other postoperative complications occurred.

When the donor site and recipient site are located in the same area of the mandibular arch, the surgical procedure is reduced to 1 incision, which gains access both to the donor bone and to the recipient site.

TABLE 4. Demonstration of Patient Data and Surgical Procedures Inclusive Survival Rates of the Placed Implants for Group 2

Patient	Age	Sex	Recipient Site*	Initial Width (mm)	Complication at Donor Site	Complication at Recipient Site	Final Width (mm) After 5 Mo	Lateral Ridge Augmentation Achieved (mm)	Number of Implants	No of Fixation Screws	Follow-Up (Mo)†
1.	44	F	28–30	3.52	None	None	7.68	4.16	3	2	13
2.	71	F	28–30	2.40	None	None	8.01	5.61	3	2	7
3.	58	M	29–30	3.17	None	Exposure	–	–	–	2	–
4.	38	F	28–30	2.93	None	None	8.03	5.1	3	2	14
5.	58	M	19	3.74	None	None	8.83	5.09	2	2	21
6.	42	F	19	3.86	None	None	9.67	5.81	2	5	10
7.	35	F	19	3.89	None	None	10.56	6.67	1	2	21
8.	32	M	19	2.97	Pain	None	7.26	4.29	1	2	14
9.	59	F	19–20	3.35	None	None	9.47	6.22	3	2	20
10.	49	F	19–20	3.64	None	None	7.89	4.25	2	3	19
11.	42	F	30	3.25	None	None	7.13	3.88	1	2	12
12.	59	M	19–20	3.83	None	None	8.84	5.01	3	2	16
Average				3.3663			8.4881	5.099			15.18

*US tooth number used.
†After delivery of prosthetic rehabilitation.

TABLE 5. Demonstration of Patient Data and Surgical Procedures Incl. Survival Rates of the Placed Implants for Both Groups

Patient	Age	Sex	Recipient Site*	Initial Width (mm)	Complication at Donor Site	Complication at Recipient Site	Final Width (mm) After 5 Mo	Lateral Ridge Augmentation Achieved (mm)	Number of Implants	No of Fixation Screws	Follow-Up (Mo)†
1.	51	F	19	4.01	None	None	9.24	5.23	2	2	36
2.	49	F	30	3.85	None	None	9.03	5.18	2	2	35
3.	41	F	19	3.97	None	None	9.32	5.35	1	2	28
4.	33	M	19–20	4.22	Pain	None	10.17	5.95	3	2	52
5.	54	M	19	3.12	None	None	9.21	6.09	1	2	57
6.	27	M	30	4.15	None	None	10.03	5.88	2	2	27
7.	50	M	30	3.24	None	None	8.53	5.29	1	2	11
8.	29	M	19–20	3.53	None	None	8.33	4.8	2	2	10
9.	54	F	29–30	2.95	None	None	8.02	5.07	3	2	8
10.	42	M	30	3.11	None	None	7.94	4.83	2	4	2
11.	24	M	30	4.21	None	None	10.13	5.92	1	2	2
12.	57	F	19–20	2.69	Pain	None	7.31	4.62	3	2	20
13.	44	F	28–30	3.52	None	None	7.68	4.16	3	2	13
14.	71	F	28–30	2.40	None	None	8.01	5.61	3	2	7
15.	58	M	29–30	3.17	None	Exposure	–	–	–	2	–
16.	38	F	28–30	2.93	None	None	8.03	5.1	3	2	14
17.	58	M	19	3.74	None	None	8.83	5.09	2	2	21
18.	42	F	19	3.86	None	None	9.67	5.81	2	5	10
19.	35	F	19	3.89	None	None	10.56	6.67	1	2	21
20.	32	M	19	2.97	Pain	None	7.26	4.29	1	2	14
21.	59	F	19–20	3.35	None	None	9.47	6.22	3	2	20
22.	49	F	19–20	3.64	None	None	7.89	4.25	2	3	19
23.	42	F	30	3.25	None	None	7.13	3.88	1	2	12
24.	59	M	19–20	3.83	None	None	8.84	5.01	3	2	16
Average				3.48			8.72	5.23			19.78

*US tooth number used.
†After delivery of prosthetic rehabilitation.

Lateral ridge augmentation has an average value of 5.23 mm measured on CBCT at 4 months after surgery in this study. For group 1 mean value is 5.35 mm and for group 2 mean value is 5.099 mm. Other studies reported similar values, respectively 5 mm[22] and 5.7 mm[23] at 6 months postoperatively, when autogenous bone grafts were used for lateral ridge augmentation. Other study reported a mean value of width gained of 3.5 mm 6 months postoperatively when used ramus bone block for lateral alveolar ridge augmentation.[24]

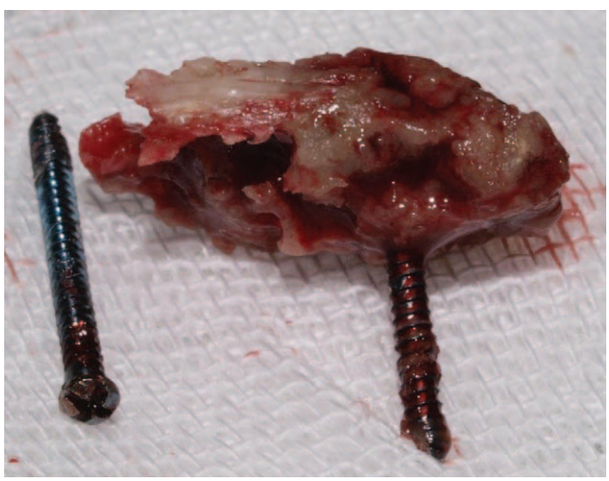

FIGURE 7. The necrosed bone block is removed.

Differences could be clarified due to different techniques, used of barrier membrane (resorbableor nonresorbable), bone substitute material, or a combination of membrane with particulate bone. Particulate deproteinized bovine bone mineral acts like a space maintainer when opposed to autogenous bone block and compensates natural bone resorption caused by remodeling.[23]

The approach described above does not change substantially the outcome of the final result in terms of volume of the graft, but it reduces the risk of graft infection and failure. Buser et al[25] described the technique of bone augmentation where bone block was covered simultaneously by xenograft particles and pericardium membrane. By delaying the interposition of xenograft particles and pericardium/collagen membranes we are lowering the risk of soft tissue dehiscence. According to Chiapasco et al[26] guided bone regeneration presents a higher risk of infection because of wound dehiscence and membrane exposure. Using only autogenous materials (bone block, bone chips, PRF, periosteum as a membrane), we are helping the bone block to revascularize obtaining a faster osseointegration.

Xenograft particles covered by pericardium/collagen membrane will be placed during the next stage, 3 to 4 months later, during implant placement. Simultaneously, we can enhance soft tissue by transforming unattached gingiva in attached gingiva around implants by using different techniques (Kazanjian, Obwegeser).[27]

In the present study, use of autogenous material (bone block, particulate bone, and PRF) in the first stage led to 100% success of ramus bone graft and to a mean value of 5.35 mm for ridge augmentation. When autogenous material was combined with other material (bovine bone substitute and pericardium membrane) in the

first stage dehiscence and graft exposure occurred, which led to 91.67% success of ramus bone graft. For this group mean value for ridge augmentation is 5.099 mm.

Survival of implants placed in ridge augmented with mandibular ramus blocks is: 93.1% according to Chiapasco et al[28] after a mean follow-up of 19 months, 96.9% according to Levin et al[29] after a mean follow-up of 24.3 months, 98.3% after 77 months according to Sethi and Kaus[30] and 99% after 2 to 6 years according to Soehardi et al.[31] In the present study survival rate is 100% for an average follow-up of 19.78 months from time of loading.

The presented technique of lateral ridge augmentation using mandibular ramus bone graft in association with PRF demonstrates successful ridge augmentation and avoids risk of wound dehiscence and further infection. Surgical technique is simplified using PRF, no adverse effect was noticed and rate of success is higher than in the original technique. Based on this study, we can conclude that lateral ridge augmentation using mandibular ramus bone graft in association with platelet-rich fibrin is a more predictable and successful technique.

It is needed to assess the grafts block branch clinically controlled studies with a larger number of patients evaluated over longer period.

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