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Primary Closure Versus Open Membrane Technique in Augmentation of Extraction Sockets

Çekim Soketlerinin Ogmentasyonunda Primer Kapamaya Karşı Açık Membran Tekniği

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**This study was presented orally at the 24th International Conference on Oral and Maxillofacial Surgery (ICOMS 2019), in Rio de Janeiro between 21-24 May, 2019.*

ABSTRACT Objectives: Funakoshi is the first one who reported "Open Barrier Membrane" technique by using non-expanded, high-density polytetrafluoroethylene(d-PTFE) membrane in 2005. d-PTFE membranes are impenetrable for bacteria invasion because of its surface characteristics and surgeon can leave the d-PTFE membrane intentionally exposed. The objective of this study was to investigate the clinical results of "Open Barrier Membrane" technique in Guided Bone Regeneration (GBR) of the extraction sockets by using xenogenic bone graft and d-PTFE membranes. In this clinical study, open barrier membrane technique was compared to GBR technique. The comparison was made between the cases where the primary coverage of extraction site was obtained and the cases who completed the 6-month recovery period without exposure in terms of total bone gain. **Material and Methods:** Fifteen patients who were reported to have exposure in incision line during 6-month recovery period were included in open membrane group as study group (Group A). Fifteen patients who completed the 6-month recovery period without exposure were analyzed in primary coverage group as control group (Group B). The main groups were also divided into subgroups as horizontal and vertical augmentation. The amount of total bone gain was statistically compared between the groups based on the cone beam computerized tomography measurements. **Results:** Vertical and horizontal bone gain amounts (the main outcome variable) were statistically compared between Group A and B. There was no statistically significant difference between these groups in terms of bone gain (p=0.237 for comparison of vertical augmentation; p=0.482 for comparison of horizontal augmentation). **Conclusion:** Open barrier membrane technique can be considered as an alternative minimal invasive technique for both horizontal and vertical alveolar augmentation procedures.

Keywords: Bone transplantation, dental implantation

ÖZET Amaç: Funakoshi ilk kez 2005 yılında d-PTFE membran kullanarak "Açık Bariyer Membran" tekniğini tanıtmıştır. d-PTFE membranları, yüzey karakteristiğinden dolayı bakteri tutulumu için olanaksızdır ve cerrah bu membranı primer kapama sağlamaksızın ağız boşluğuna açık bırakabilir. Bu çalışmanın amacı çekim soketlerinin ksenojenik kemik grefti ve d-PTFE membran kullanılarak gerçekleştirilen yönlendirilmiş kemik rejenerasyonu prosedürlerinin klinik sonuçlarının araştırılmasıdır. Bu çalışmada d-PTFE membranın üzerinin açıldığı vakalar (açık membran tekniği) ile 6 aylık süreç boyunca hiçbir açıklık gerçekleşmeyen vakalar arasında, kemik kazanımı bakımından karşılaştırma yapılmıştır. **Gereç ve Yöntemler:** İnsizyon hattında açıklık meydana gelen 15 hasta çalışma grubu olarak açık membran grubuna dahil edilmiştir (A Grubu) ve 6 aylık iyileşme sürecini hiç açıklık meydana gelmeden tamamlayan 15 hasta kontrol grubu olarak primer kapama grubunda analiz edilmiştir (B Grubu). Ana gruplar ayrıca horizontal ve vertikal ogmentasyonlar olarak alt gruplara ayrılmıştır. Toplam kemik kazancı miktarı gruplar arasında, konik ışınlı bilgisayarlı tomografi üzerinde yapılan ölçümler üzerinden istatistiksel olarak karşılaştırılmıştır. **Bulgular:** Yeni kemik kazanım oranı göz önünde bulundurulduğunda açık bariyer membran tekniği ve primer kapamanın sağlandığı konvasiyonel yönlendirilmiş kemik rejenerasyonu prosedürü arasında klinik olarak anlamlı bir farklılık görülmemiştir (p=0,234 vertikal ogmentasyon karşılaştırılması; p=0,481 horizontal ogmentasyon karşılaştırılması). **Sonuç:** Açık bariyer membran tekniği horizontal ve vertikal alveoler ogmentasyon prosedürleri için alternatif bir minimal invaziv teknik olarak düşünülebilir.

Anahtar Kelimeler: Kemik transplantasyonu, diş implantasyonu

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Guided bone regeneration (GBR) is a well known technique by oral and maxillofacial surgeons. Resorbable and non-resorbable membranes are commonly used in all over the world (Figure 1). Excellent results are obtained in animal studies but high failure rates associated with instability, infection, and exposure of the graft have been reported in clinical practice.[1-5] Wound dehiscence and membrane exposure are the major risks during the GBR protocols. Membrane exposure can lead to bacterial invasion on the graft site and result in graft infection. Solution methods to avoid the graft exposure during the bone regeneration period have been still investigated. Several surgical techniques like periosteal releasing incisions, exaggerated dissections under general anesthesia or soft tissue expanders before augmentation procedure have been recommended to minimize the graft and membrane exposure rates and maintain the soft tissue closure.[6-10] But all of these surgical interventions have postoperative complications such as increased swelling and pain.[11]

Expanded polytetrafluoroethylene (e-PTFE) membrane has been commonly used for guided bone regeneration procedures in implant dentistry.[11] Even its strong mechanical structure is suitable to protect the bone volume in grafted region, its surface does not act as a strong barrier to avoid bacterial invasion. High density membrane structure is produced to increase the barrier capacity of polytetrafluoroethylene membrane. Funakoshi is the first who reported "Open Barrier Membrane" technique by using non-expanded, high-density (d-PTFE) membrane in 2005. d-PTFE membranes are impenetrable for bacteria invasion because of its surface characteristics and the surgeon can leave the d-PTFE membrane intentionally exposed.[11]

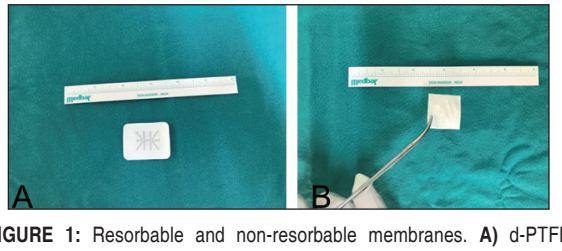

FIGURE 1: Resorbable and non-resorbable membranes. **A)** d-PTFE membrane **B)** Collagen membrane.

The objective of this study was to evaluate the clinical results of "Open Barrier Membrane" technique in GBR of the alveolar ridge by using xenogenic bone graft and d-PTFE membranes. In this clinical study, horizontal and vertical bone gain capacity of open barrier membrane technique were compared to conventional GBR technique where the primary coverage was obtained in both immediate and post-extraction sites.

MATERIAL AND METHODS

This clinical study was ethically approved by Baskent University Institutional Review Board (Project no:D-KA18/01 Date: 12-10-2018).

The study was conducted in accordance with the Declaration of Helsinki Principles.This retrospective clinical study was performed on patient's extraction sockets who underwent GBR procedure via a non-resorbable membrane by the same surgeon between June 2017 and February 2018 at Başkent University Department of Oral and Maxillofacial Surgery.

Inclusion criteria:

- Patients who presented to dental outpatient clinic demanding for dental implants, but who did not have adequate bone volume in horizontal or vertical dimension,
- Successful implant placement could be obtained in all grafted sites,
- Patients who had preoperative and sixth month postoperative cone beam computerized tomography (CBCT) images.

Exclusion criteria:

- Smoking,
- Patients who had periodontal disease,
- Patients who had any systemic disorder, such as hypertension, diabetes, rheumatic disease or neurologic disease,
- Patients who needed revision for only bone grafting procedure,
- Patients whose implant placement could not be performed at grafted region.

Age, sex, location of the defect, graft size, and complications of the patients were analyzed from the patients'data. Also preoperative and sixth month postoperative (just before implant surgery) CBCT measurements were recorded. Patients were divided into two main groups.

Study group (Group A) included the patients who had exposure in incision line (open membrane technique) and control group (Group B) included the patients who completed the 6-month recovery period without exposure at grafted region. The surgeon tried to maintain primary closure in all augmentation procedures, however some of the cases in the study group had exposure during the healing period. Two main groups were divided into two subgroups as follows:

1) Vertical augmentation group: the height of alveolar ridge was increased,

2) Horizontal augmentation group: the width of alveolar ridge was increased,

Immediate socket terminology was used for augmentation procedure that was performed simultaneously with tooth extraction because buccal bone was partially or completely resorbed. Post-extraction socket terminology was used for augmentation which was performed at healed alveolar bone late after extraction.

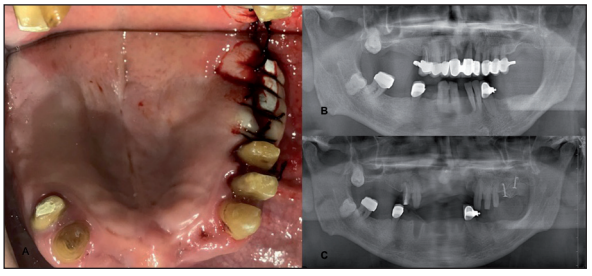

FIGURE 2: A) Open membrane at incision line (post extraction socket). **B)** Preoperative radiographic view **C)** Postoperative radiographic view.

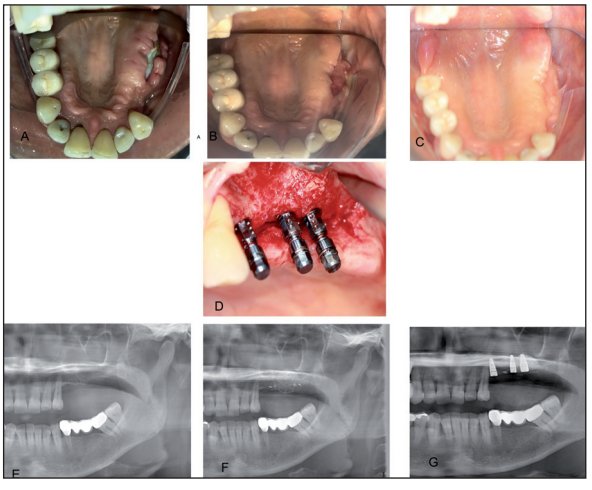

FIGURE 3: A case in open membrane group **A)** Incision line after sutures removed **B)** Incision line after membrane removal (4 weeks after surgery) **C)** Incision line after membrane removal (12 weeks after surgery) **D)** Implant surgery at augmented region **E)** Preoperative radiographic view **F)** Postoperative radiographic view **G)** Periapical radiography after implant surgery.

SURGICAL PROCEDURE

Informed consent form was obtained from all patients before the surgery. Bone augmentation procedure was performed under local anesthesia. After reflection of the mucoperiosteal flaps, bone substitute combined with platelet rich fibrin and autogenous graft was placed onto the deficient ridge where a d-PTFE membrane was then placed over the site (Figure 2). The flaps were repositioned and sutured with periosteal releasing incisions. As the first step, bone grafting was performed to all patients. Six months after the bone grafting surgery, implants were placed. Bi-Oss (Geisthlich, Switzerland) was utilized as bone graft and d-PTFE membrane (Cytoplast® GBR-200, TXT-200, Osteogenics) was used as membrane. Autogeneous bone graft chips were collected by using a bone scrapper from the distal or mesial side of the recipient site. d-PTFE membrane was fixed with 3 or 4 micro-screws. The d-PTFE membrane was removed 4 to 6 weeks after surgery under local anesthesia in exposure group (Figure 3). The d-PTEF membrane was removed at 6th month during implant surgery in control group.Follow-up examinations were performed at 3rd, 7th, 15th, 21st and 28th days for open membrane group and 0.12% chlorhexidine gluconate rinse was used as an effective antiplaque agent to avoid infection in exposure lines.

CBCT EVALUATION

Preoperative and postoperative radiologic assessments were performed by CBCT system (3D Accuitomo 170, Morita Japan) to evaluate volumetric

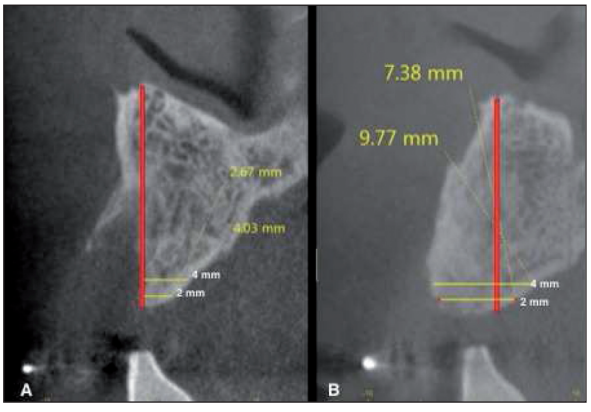

FIGURE 4: Preoperative and postoperative CBCT assessment **A)** Preoperative CBCT view **B)** Postoperative CBCT view (6 months after surgery).

changes. Images were acquired with standart technical parameters (90 kv, acceleration voltage 5 mA beam current, field of view, 17,5.s) before surgery and 6 months after bone grafting. All bone gain measurements were performed using the measuring tools available in the software. Anatomic landmarks were used to create relatively same reference lines on preoperative and postoperative CBCT images.

Vertical bone gain evaluation: In the upper jaw, the nasal cavity, sinus base, spina nasalis anterior or apex of the adjacent tooth root; in the lower jaw, the mental foramen, upper border of mandibular canal were used as anatomic landmarks. Reference lines tangent to these anatomic landmarks were formed. The amount of vertical bone gain was evaluated using the reference lines. The distance from the origin of the vertical defect to the reference line and the distance from the apex of the crest to the reference line were measured.

Horizontal bone gain evaluation: The amount of horizontal bone gain was evaluated at spesific levels (2-4 mm apical to the top of the alveolar crestal bone). Ridge width (RW) was the distance between the buccal and palatal bone plates at 2 mm and 4 mm apical to the crestal bone and mean ridge width was calcuated (Figure 4).

STATISTICAL ANALYSIS

Statistical Package for Social Sciences for Windows (SPSS), version 20 was used for statistical analysis with 95% confidence interval. Chi square test was conducted to detect the relationship between gender and groups. Mann Whitney U test was used to determine if there was a significant difference between groups in terms of bone gain rates. Vertical and horizontal bone gain of Group A and Group B was statistically compared. Among the immediate and post extraction socket cases, the statistical comparison of the vertical and horizontal bone gain between Group A and Group B was also made.

RESULTS

Fifteen patients who were reported to have exposure in incision line were included in open membrane group as study group (Group A) and 15 patients who completed the 6-month recovery period without exposure were analyzed in primary coverage group as control group (Group B).

None of the patients reported any sign of infection and/or any level of gingival inflammation during the surgical interventions even though the d-PTFE membranes were partially exposed in study group. During the d-PTFE membrane removal, it was observed that newly formed bone was covered by a smooth red non-epithelialized soft tissue. Tissue was re-epithelialized completely within 1 month in study group and premature bone was totally covered with keratinized oral epithelium.

Table 1 gives demographic information about age and sex distribution, Table 2 shows number of horizontal and vertical augmentation procedures, alveolar ridge types, initial and final bone amount in Group A and Group B.

According to the findings of immediate extraction sockets, the total vertical and horizontal bone gain

TABLE 1: Demographic data of patients in Group A and Group B.

		Sex		
		Male	Female	Age
A	n	9	6	63.3 (±) (11.2)
	%	60.0%	40.0%	
B	n	8	7	53.7(±) (10.6)
	%	53.3%	46.7%	
Total	n	17	13	58.5 (±) (10.8)
	%	56.7%	43.3%	

TABLE 2: Number of horizontalandverticalaugmentationprocedures, alveolarridgetypes, initialand final bone amount in Group A and B.

		Augmentationprocedure		Ridgetype		Initialand final bone amount		
		Horizontal	Vertical	Immediate extraction socket	Post extraction socket	Mean residual alveolar bone amount (mm)	Mean Post operative 6th month alveolar bone amount (mm)	Bone gain rate (%)
A	n	5	10	5	10	4.2 (±)1.3	8.9(±)2.6	22.5(±)62.7
	%	33.3%	66.7%	33.3%	66.7%			
B	n	6	9	7	8	3.9 (±)1.2	8.5(±)2.6	129(±)75.7
	%	40.0%	60.0%	46.7%	53.3%			
Total	n	11	19	12	18	4.0(±)1.2	8.7(±)2.5	125.8(±)68.4
%	36.7%	63.3%	40.0%	60%				

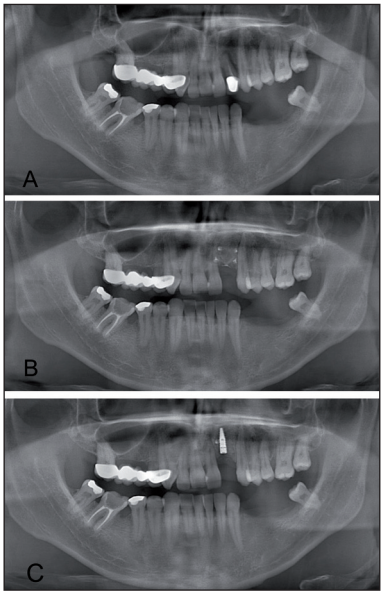

FIGURE 5: A) Immediate anterior extraction socket augmentation preoperative view **B)** Immediate anterior extraction socket augmentation postoperative view **C)** Postoperative radiographic view of augmented site after implant surgery.

TABLE 3: The statistical comparison of total vertical and horizontal bone gain between Group A and Group B in immediate extraction sockets.

		n	Median	Min-Max	p
Vertical augmentation	A	5	96.6	68.3-200.0	0.222
	B	5	224.3	89.7-284.6	
Horizontal augmentation	A	1	200	200.0-200.0	0.668
	B	2	150	100.0-200.0	

between Group A and Group B was statistically compared (Figure 5). No statistically significant difference was observed between these groups (Table 3).

Among the patients who underwent augmentation procedure at post-extraction period (Figure 6), the total vertical and horizontal bone gain-between GroupA and Group B was statistically compared. There wasn't any statistically significant difference between these groups (Table 4).

Regardless of the socket types defined as immediate and post extraction, vertical and horizontal bone gain amounts (the main outcome variable) were statistically compared between Group A and B. There was also no statistically significant differ-

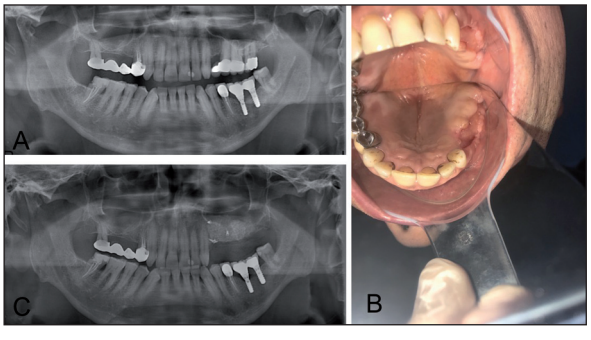

FIGURE 6: A) Immediate posteriorextraction socket preoperative radiographic view **B)** Incision line after membrane removal (6 weeks after surgery) **C)** Immediate posterior extraction socket postoperative radiographic view.

TABLE 4: The statistical comparison of total vertical and horizontal bone gain between Group A and Group B in post extraction sockets.

		n	Median	Min-Max	p
Vertical augmentation	A	5	155.8	78.6-210.5	0.286
	B	4	108.2	53.8-125.0	
Horizontal augmentation	A	4	67.9	35.1-79.4	1.000
	B	4	56.9	47.1-100.0	

TABLE 5: The statistical comparison of the amount of vertical and horizontal bone gain between Group A and B.

		n	Median	Min-Max	p
Verticalaugmentation	A	10	126.2	68.3-210.5	0.234
	B	9	125.0	53.8-284.6	
Horizontalaugmentation	A	5	71.4	35.1-200.0	0.481
	B	6	83.4	47.1-200.0	

ence between these groups in terms of bone gain (Table 5).

DISCUSSION

Several studies have shown that the most common complication in the recipient field is the dehiscence in the line of incision in the augmentation of the localized alveolar defects.[3,4] In their study conducted in 1990, Buser at al. reported a gain of 1.5 mm to 5.5 mm in bone formation with the guided bone regeneration technique; however, an acute infection developed in three patients out of 12, requiring an early removal of the membranes.[12] The sufficient and stable bone coverage techniques for augmentation procedures have been still investigating to avoid this common complication. The current study proved that open membrane technique could reliably protect augmented bone vertically or horizontally from infection and exposure of membrane was not a further problem for clinicians.

Chiapasco et al. compared the patients who underwent augmentation procedures with particulate grafts and membranes with the patients who underwent augmentation only with block bone grafts according to the amount of bone gain after six months of the procedure.[13] The authors reported a bone gain of 2.4 mm in the first group, where the patients underwent GBR, and a bone gain of 4 mm in the second group, where block bone grafts were used alone. A lesser amount of bone gain was achieved with GBR and some complications were reported. Exposure of the membranes occurred in two patients out of 15. These membranes had to be removed due to risk of deformation in bone regeneration. An implant surgery was performed in 14 out of the 15 cases included in the study. A further grafting process using a block graft was required in one patient in order to regenerate a sufficient bone volume. They concluded that GBR revealed a higher risk of infection due to the potential of developing wound dehiscence and exposure of the membranes.[13]

A wide range of resorbable and non-resorbable membrane materials such as polytetrafluoroethylene, e-PTFE, titanium mesh membranes, collagen, polylactic acid, poly-glycolic acid, and their copolymers have been used in experimental and clinical studies in order to prevent wound dehiscence, exposure and infection.[14,15] Every membrane type has both advantages and disadvantages. The maintenance of the integrity of the bone graft is necessary to achieve a successful bone augmentation. That is why the use of screws, and titanium meshes are very common today.[14,16-18] On the other hand, the use of these methods increases the complexity of the surgery along with the increased duration and cost of the procedures because implanting usually requires the creation of relatively wider flaps in the oral cavity, increasing the risk of dehiscence in the soft tissue. For these reasons, the emergence of clinical complications followed by failures is rather common with a rate of 20-60% in the autogenous bone grafts fixed with screws or titanium meshes.[19] As a result, there is a significant need to develop alternative methods to achieve easier and safer interventions.

Recently d-PTFE membrane has been designed specifically for bone-augmentation procedures.[20] The d-PTFE is cell occlusive, shows minimal inflammation when exposed to the oral cavity, and does not integrate with the tissue for membrane stabilization.[20] d-PTFE membrane can be applied with preferred graft materials via minimally invasive procedures and they can remain fixed on the original surfaces of the bones without any emerging exposures so that the risk of infection can be reduced and a good mechanical stability can be achieved. The usage of d-PTFE membrane can diminish infection risk and graft lost in GBR.[19] However clinical and histological evidence for the use of d-PTFE membranes is still limited.[21,22]

The open membrane technique first introduced by Funakoshi in 2005 appears to create a paradigm shift.[23] The surface properties of the non-expanded, high-density d-PTFE membranes used in this technique do not allow bacterial adhesions. Therefore, the surgical sites can be left open without primary closures. The advantages of this technique may include the absence of periosteal incisions, a comfortable healing process in the postoperative period, a lesser amount of developing edema, and a more comfortable postoperative period for the patient and the surgeon.[11,23,24]

In a recently published research, Mandarino et al.evaluated the newly formed tissues in postextraction sockets and compared ridge dimensional changes with and without the use of a d-PTFE membrane.[25] Twenty human extraction sockets received either an intentionally exposed d-PTFE membrane (test group) or no biomaterial (control group). Authors reported that ridge preservation using a d-PTFE membrane was found to increase the formation of keratinized tissue of gingiva. Also it was reported that using d-PTFE membrane alone for socket preservation did not have any protection capacity for reduction in width or height of the alveolar ridge in first 4 month of healing period.[25]

A thin layer of soft tissue covering grafted bone was observed during the d-PTFE membrane removal session in all of the patients included in study group. This thin layer initially had a darker color than gingiva due to its rich blood supply.This newly formed thin mucosa clinically became stronger and keratinized in healing period same as Mandarino et al.'s clinical findings.[25] At the end of 6 month healing period, this layer gained the same clinical features as healthy oral mucosa.[11]

Induced membrane (IM) is a biologically active membrane, which is the result of foreign body reaction. IM contains good vascularity, secretory growth factors, and mesenchymal adult stem cells. IM technique is first described by Masquele et al., which is used for over 30 years. Masquele has presented this technique as an alternative to Ilizarov's distraction osteoegenesis and vascular bone graft techniques. It has recently become increasingly popular worldwide because it is simple and effective for restructuring mental bone defects. Firstly, the bone is defined as the septic non-union consequence of bone loss encountered. Then, regardless of the etiology of bone loss, it has begun to be used for the reconstruction of all long bones, including the clavicle.[26,27] According to Masquele's IM technique, bone cement is used as a spacer for 4-6 weeks to create induced membrane. After bone cement removal, the membrane that is induced by the cements is left in place and the cavity is filled up by autograft or bone substitute. IM has been shown to have 2 major roles in the promotion of bone healing: First, the membrane has the ability to prevent resorption of non-vascularized autograft and second, it can produce factors associated with bone healing.[26-30] We hypothesized that the soft tissue observed after d-PTFE membrane removal, had the same characteristic features as induced membrane and we believed that d-PTFE membrane acted as a foreign body just like bone cement in Masqule technique. Further comprehensive histological investigations are needed to understand the effect of d-PTFE material on both bone graft and covering mucosa.

The results of the current study supported that d-PTFE membrane was not only a reliable barrier to avoid bacterial invasion into the grafted site but also it allowed overfilling of the graft. The clinical comparison of open membrane technique and conventional GBR with primary soft closure showed that there was not any significant difference between two techniques when new bone formation ratio was considered.

CONCLUSION

Non-expanded dense PTFE membranes provide sufficient and stable regenerated bone volume suitable for implant placement. Not surprisingly, using d-PTFE membrane facilitates the overfilling of augmentation site because primary coverage is not required and this feature helps the surgeon especially in immediate extraction sockets which primary soft tissue coverage is difficult. Open barrier membrane technique can be a new standard for both horizontal and vertical alveolar bone augmentation.

Disclosures

This study was approved by Baskent University Institutional Review Board (Project No: D-KA18/01).

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

All authors contributed equally while this study preparing.

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