

The influence of peripheral-bone-removal protocol on bone augmentation in dental implant surgery: 5-year clinical retrospective study

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ABSTRACT

Background: Bone augmentation aims to provide sufficient bone volume around dental implants. Available bone augmentation methods include autogenous bone grafts, xenografts, and alloplastic materials. All have their advantages and disadvantages. However, autogenous bone graft remains the gold standard for bone augmentation. Autogenous bone grafts are usually taken from the patient's oral donor sites such as the chin and mandibular ramus. However, there is a newly developed implant preparation protocol, known as the peripheral-bone-removal (PBR) technique, which can provide bone augmentation from the dental implant site. **Purpose:** This study aims to determine the need for bone substitute materials in the PBR technique in dental implant surgery. **Methods:** This study included 130 patients who were treated for dental implants. These patients were treated between 7.1.2018 and 3.2.2023. Six dental implant systems were used. Five of these systems (ImplantKa[®], DeTech[®], NeoBiotech[®], Easy Implant[®], and Dentaurum[®] Implant) used a conventional method (sequential drilling technique). The sixth (IBS[®]) system used the PBR protocol. Both descriptive and Chi-Square Test statistics were used for data analysis. **Results:** The included patients were treated with a total of 198 dental implants. Seventy patients were treated with the PBR protocol, while 60 patients were treated with the sequential drilling protocol. For the PBR protocol, only 2 cases required bone substitute material, whereas 11 cases treated with the sequential drilling protocol required augmentation materials. This difference between both drilling protocols has been statistically confirmed ($P=0.008$). **Conclusion:** The PBR technique appears to be less traumatic and more cost-effective for cases that require horizontal bone augmentation.

Keywords: dental implant; bone graft; bone substitute; sequential drilling protocol; peripheral-bone-removal protocol

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INTRODUCTION

Due to its high success rate, dental implant treatment is now a widely accepted option for replacing missing dentitions worldwide.^{1,2} However, this success can be challenged by different systemic and local factors, such as inadequate alveolar bone support. Alveolar bone atrophy after tooth extraction could exert a significant risk for dental implant failure. It is agreed that adequate bone volume is a crucial factor for dental implant success,^{3,4} as adequate bone volume provides the necessary primary stability for dental implants.^{5,6}

Therefore, different methods have been suggested to address alveolar bone deficiency around dental implants. These methods are alveolar ridge splitting, bone expansion,³ autogenous bone grafts,⁷ and bone substitute materials.⁸ Bone substitutes could be allografts, xenografts, or alloplastic materials.⁹ All have their advantages and disadvantages. However, autogenous bone graft remains the gold standard for bone augmentation.^{10,11}

Autogenous bone grafts for dental implant support are usually taken from the chin and the mandibular ramus.¹¹ This is considered a major disadvantage, as it adds donor site morbidity and increases the chance of surgical infection

and complications. However, a newly developed implant preparation protocol, known as the peripheral-bone-removal (PBR) technique,¹² can provide bone graft from the dental implant site itself. This study aims to determine the need for bone substitute materials in the PBR technique in dental implant surgery.

MATERIALS AND METHODS

Ethical approval for this observational retrospective study was obtained from the Ethical Committee at Ibn Sina University for Medical and Pharmaceutical Sciences (ISU.4.1.23). One hundred and thirty patients who received dental implant treatments at a single dental center in Baghdad were included in this study. Their data were collected from the Basmat Training Dental Center database. These patients were treated between 7.1.2018 and 3.2.2023 by the first author (FA). Patients' data were reviewed and the following variables were recorded: age, sex, implant zone (upper anterior, upper posterior, lower anterior, and lower posterior zones), timing of implant (immediate vs delayed), the need for bone augmentation, sinus lifting procedure, dental implant system, and immediate-term success/failure.

Two different dental implant drilling protocols were used in this study: conventional (sequential drilling protocol) and PBR protocol. Five systems (ImplantKa[®], DeTech[®], NeoBiotech[®], Easy Implant[®], and Dentaurum[®] Implant) used conventional protocol. The sixth (IBS[®]) system used the PBR protocol.

The conventional sequential drilling protocol is a well-established surgical protocol in dental implant treatment.

Although dental implant companies have their specific surgical kits, this protocol is generally based on a calculated increase in the drill size to reach the desired diameter of the drill, which matches the intended implant diameter.¹³

The PBR protocol, on the other hand, uses a single drill (Magic Drill) designed for each implant diameter. This specifically designed drill is a hollow drill that prepares the implant bed through the peripheral cutting of the bone socket. This design allows the central part of the prepared bone to remain inside the socket, or it may be lifted within the drill and retrieved using a special retrieval instrument. This bony piece usually has a cylindrical shape, and its size follows the diameter and length of the drill (Figure 1).

Before the implant procedure, antibiotics are prescribed prophylactically as a single dose measure (500 mg Amoxicillin 1hr before the surgery).¹⁴ Immediately before the procedure, the patient is asked to rinse his/her mouth with Chlorhexidine mouthwash (0.12%) for 1min.¹⁵ All dental implant treatments were performed by the first author FA. The procedures that used the PBR technique¹² were done using the flapless mode¹⁶ to minimize surgical trauma by avoiding mucosal flap reflection.¹⁷

The procedure starts with a soft tissue punch using 1500 RPM speed. To ensure appropriate implant positioning, preliminary drilling to a depth of 3 mm is used to assess the appropriateness of the drilling direction before proceeding with the complete drilling procedure. The peripheral bone-cutting procedure then continues with the Magic Drill. By the end of the drilling, a bone core piece will either remain inside the socket or be located within the drill. This piece will be kept as a bone graft material in a small metal container soaked in physiological saline to preserve osteocyte vitality.

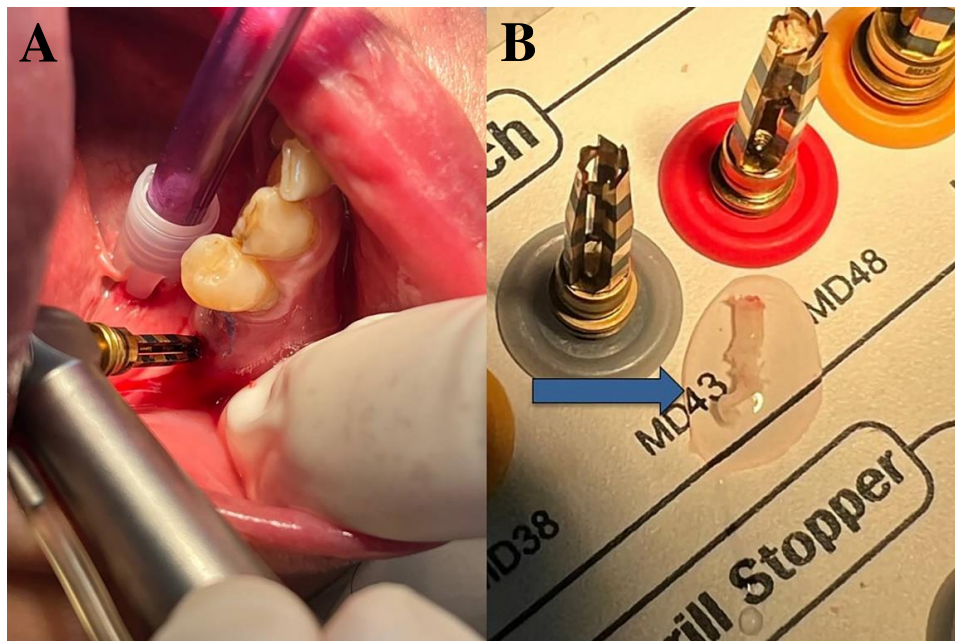


Figure 1. Peripheral Bone Removal using the Magic Drill to prepare the implant socket (A) and the bone core material isolated from the prepared implant socket site (B).

In cases that use the PBR protocol, once the implant is inserted and secured in its position, a 3-5mm vertical tunnel is created from the buccal aspect of the soft tissue punch to accommodate the bone graft (external socket technique) (Figure 2). The bone graft is secured in place using a single simple interrupted suture.

On the other hand, when conventional drilling protocol is used, the bone substitute is performed using alloplastic material (Bioplast-Dent®) Bone particles are mixed with physiological saline and inserted at the buccal defect using the tunneling technique.^{18,19} However, with the alloplastic material, more room is created to minimize the expected pressure from the flap after suturing, which might increase the chance of resorption of the grafted material.

After securing the bone augmentation material, a horizontal mattress suture is done and kept for 10 days. The patients are asked to maintain optimum oral hygiene levels with continued mouthwash for 10 days, or the implant is completely covered by oral epithelium.

Three months after the initial surgery, a radiographic assessment is conducted during the second visit to evaluate the bone healing around the implant. The immediate-term success of osseointegration^{20,21} is confirmed clinically by implant stability during replacement of the cover-screw by the healing abutment.²²⁻²⁴

Inclusion criteria: all dental implant cases treated with both protocols within the defined time frame where the patient’s data are complete. Exclusion criteria: patients with

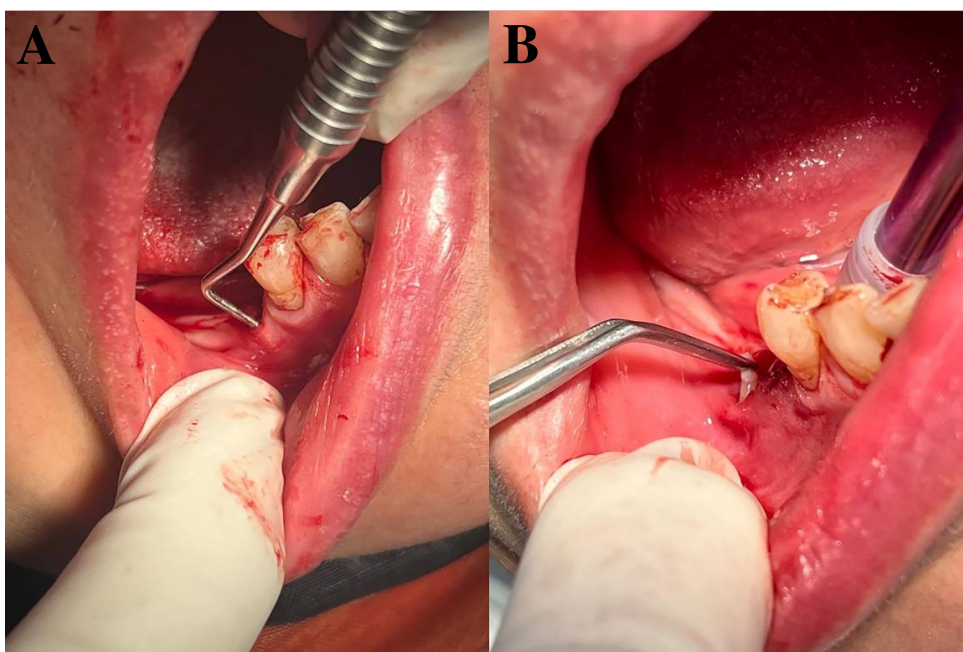


Figure 2. Buccal pocket (buccal to the implant socket) to accommodate the bone graft (A), and insertion of the bone graft material (bone core material, see Figure 1B) within the buccal pocket to increase buccal bone width (B).

Table 1. Study biographic

Variable	No. of implants	%
Sex		
Females	129	65.2
Males	69	34.8
Implant side		
Right side	111	56.1
Left side	87	43.9
Implant zone		
Upper arch	112	56.6
Lower arch	86	43.4
Upper anterior	33	16.7
Lower anterior	7	3.5
Upper posterior	82	41.4
Lower posterior	76	38.4

Table 2. Descriptive statistics for both drilling protocols

Variable	PBR		Sequential drilling		P value
	No. of implants	%	No. of implants	%	
Sex					
Males	37	35.6	32	34	
Females	67	64.4	62	66	
Timing of implant placement					
Delayed	95	91.3	73	77.7	
Immediate	9	8.7	21	22.3	
Sinus lift					
	6	5.8	6	6.4	1.000
The need for bone substitute					
	2	1.9	11	11.7	0.008
Immediate-term success					
	96	92.3	89	94.7	0.575

systemic diseases, patients treated with bone expansion technique, and patients whose data were incomplete.

Both descriptive and inferential statistics were used for the data analysis. The Chi-Square Test was used to determine the relationship between the level of immediate-term success for both protocols and the relationship between surgical protocol and the need for bone substitute materials. SPSS Version 25 was used for the statistical analysis. *P* value <0.05 was considered to determine the statistical significance.

RESULTS

One hundred and thirty patients were included in this study. The mean age for the included patients was 46.97 years, with a 2 to 1 female-to-male ratio. Table 1 provides the total number of males and females included in the study. There were a greater number of right-side cases than left-side cases. In addition, upper dental implants were more common than the lower counterpart arch. The highest percentage of implants in this study was reported in the upper posterior zone, whereas the lowest percentage belongs to the lower anterior zone. Thirty-four patients were treated with 2-6 dental implants.

Seventy of the included patients were treated with the PBR protocol (IBS[®]), whereas 60 patients were treated with the sequential drilling protocol. The included patients were treated with a total of 198 dental implants. Ninety-four dental implant cases were sequential drilling protocol cases, whereas 104 cases were PBR cases. Table 1 shows general descriptive statistics for the included cases.

The shortest implant used in this study was 7mm (IBS[®]), whereas the longest implant used was 13mm (IBS[®]). The narrowest used implant was 2.5mm (Dentium[®]), and the widest diameter was 5.5mm (IBS[®]).

Table 2 shows the descriptive statistics for both drilling protocols. Male-to-female percentages for both protocols are comparable, as are sinus-lift procedures and the level of early success dental implants. The table shows that immediate implant procedures in the sequential protocol were higher than in the PBR protocol. It also shows that the need for bone substitute material was higher in the sequential protocol compared to the PBR protocol.

Immediate-term success reported in this study for all cases was 93.6%. There was no statistically significant difference (Chi-Square Test) in the success level between both dental implant drilling protocols (Table 2). The study results show that only 2 cases needed bone substitute materials in the PBR protocol, whereas 11 cases in the conventional sequential drilling protocol needed bone substitute materials. This has been statistically confirmed. The Chi-Square Test showed a highly significant difference (*P*=0.008) between both protocols (Table 2). Of the 13 cases treated with bone augmentation material, 1 reported early dental implant failure. This case was treated with the sequential drilling protocol.

DISCUSSION

The Branemark protocol to ensure osseointegration has been the main dental implant socket preparation approach over the last 4 decades.²⁵ Osteotomy is usually performed using a series of drills, a counter sink, and final tapping.^{26,27} In this protocol, the osteotomy site is increased gradually with calculated speed and copious irrigation to minimize the damage to the tissue at the preparation site.

The Branemark approach using sequential drills has been the mainstream surgical protocol for decades. This is supported by the high success rate for different dental implant systems.^{23,28} This protocol has several advantages. Compared to the single drill protocol, it has been found to have less thermal trauma to the bone.²⁹ Gradual increase in the drill size makes it easier for the clinician to drill the site with minimum pressure and heat generation. It also reduces the chance of a change in the angle of drilling and minimizes crestal bone shattering.¹³

Recently, however, different surgical protocols have been introduced to improve the surgical outcome. Some of these protocols aim to overcome poor bone quality around the dental implants using osteotomy spreaders or under-sized drilling. This allows condensation of the cancellous bone around the implant and improves implant primary stability.²⁸ Other recently introduced protocols suggest the use of a single drill technique. The available literature shows reasonable outcomes of single drill protocols.^{30–32}

The PBR technique can be considered as a single drill technique. However, it has its specifications. The drill is based on a hollow design through which the socket is prepared not by bone drilling but rather by peripheral bone cutting. This is achieved by 3 sharp blades joined at the apex of the drill. This drill is usually used with a speed up to 2000 rpm. Working with a minimum drilling time within 25N torque will not cause high-temperature elevation.³³

The reason behind the immediate-term success of the PBR protocol could be attributed to two factors. The first factor is the hollow drill design, which appears to minimize both mechanical and thermal trauma. The second factor is the time of bone drilling. There is a single use of the drill for socket preparation, which further reduces the chance for additional bone trauma. This advantage has been reported with other single-drill protocols.^{30–32}

Furthermore, this method limits the bone contact during the drilling process and preserves most of the bone of the socket. This minimally invasive design achieves an important prerequisite for implant success.³⁴ This drill design provides autogenous bone graft material from the same socket. This advantage has not been given enough attention in the literature.

Bone augmentation has been utilized to facilitate dental implant treatment. It provides the solution for conditions of reduced bone quantity.³⁵ Bone augmentation is either performed using a tissue graft from a donor of the same species (allograft), a graft of tissue harvested from the patient (autograft), tissue harvested from a species other

than human (xenograft), or synthetic graft material (alloplastic material).¹

Autografts are considered the gold standard in bone augmentation. They are biocompatible, non-immunogenic, osteoinductive, osteoconductive, and have osteogenic properties.^{10,36,37} Alternative bone augmentation solutions have their advantages and disadvantages. However, there is no conclusive evidence in the literature regarding the superiority of one over the other in the long term.³⁸

This is, to the best of the authors' knowledge, the first study on the need for bone substitute materials in the PBR technique. In this study, two types of bone augmentation materials were used: autogenous bone graft for cases with the PBR technique and alloplastic bone substitute material for cases with the sequential drill technique. The autogenous bone block taken from the implant socket precludes the need for any bone substitute in most cases. This explains the minimal need for bone substitute material in the PBR technique.

The major advantage of bone grafts produced by the PBR technique compared to other autogenous bone graft options is there is no additional surgery on other surgical sites. During the preparation of the implant socket with the PBR technique, a core of cylindrical bone remains undamaged within the socket. This bone piece serves as an excellent bone graft material, as there will be no extra-surgical site morbidity,^{9,11,35,39} time, or cost. The bone graft block material is taken from the implant socket itself. The surgeon directly benefits from this graft material without additional surgical procedures. The other advantage is the block form of the bone graft itself, which makes it easy to manipulate, carry, and introduce into the created space. It is easy to be maintained on the site without the need for extensive suturing.

The utilization of a bone block as a bone graft from the implant socket with no additional surgical site morbidity shortens the surgical time, reduces the surgical trauma, and reduces the dentist's stress. In addition, shortened surgical time and less trauma decreases postoperative pain and discomfort for the patient.¹¹

Furthermore, the bone block retrieved from the implant socket is mostly cancellous. This facilitates the ingrowth of newly formed blood vessels. Its osteoprogenitor cells can work with the endogenous chemotactic, mitogenic, angiogenic, and growth factors to provide a faster and more predictable healing process.^{9,40} Moreover, it enjoys the same benefit of intra-oral graft sites being of a similar embryological type to the recipient site, which decreases its resorption.⁴¹

Autogenous bone graft from the implant socket, unlike other autogenous grafts,⁴² might not be the first choice for large bony defects.³⁹ Still, bony defects for most single dental implant cases are not usually sizeable and do not require large bone augmentation material. This has been confirmed by this study's findings.

It is possible to argue that such protocol could influence different treatment outcome aspects. However, this

protocol has not been studied thoroughly. Further studies are required to determine the influence of this drilling protocol on the treatment outcome in terms of healing time and patient-based evaluation. This research has one main limitation, which is the retrospective nature of the study. Retrospective studies do not allow the researcher to control the data's nature and availability, which could limit its value as evidence-based research. In conclusion, the PBR drilling technique appears to be less traumatic and more cost-effective for cases when horizontal bone augmentation is required.

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