

## The role of bone ring technique for bone augmentation in implant surgery: A Narrative Review

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### Abstract

Bone grafting with simultaneous implant placement using the novel bone ring technique was a procedure introduced with the intention of three-dimensional bone augmentation with simultaneous implant placement in both maxilla and mandible. A ring-shaped bone is placed in the socket, which is secured by an implant placed through the ring. The current narrative review was planned to provide a concise summary of the core concepts surrounding bone augmentation, to provide context for understanding the bone ring technique, and to highlight the basics of bone grafting and the origin of the technique to its advancement and its importance in the light of current literature.

**Keywords:** Dental implants, Bone augmentation, Bone grafting, Guided bone regeneration.

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### Introduction

Placement of an implant has become more frequent over the years, and offers a promising replacement for missing teeth.<sup>1</sup> However, a prerequisite for their placement is the presence of adequate surrounding bone, which is often compromised when dental extractions are warranted.<sup>2</sup> Post-extraction bone-loss may further compromise aesthetics around a fixed prosthesis and lead to gingival recession or compromise primary stability during implant placement, necessitating bone augmentation.<sup>2</sup> Bone augmentation can be defined as an alveolar ridge augmentation procedure that helps to improve the shape and size of the ridge, so it can better retain dental implant hardware. However, for the most favourable results, a combination of the appropriate case selection, type of graft material and alveolar augmentation technique is required.<sup>3</sup>

Bone augmentation is indicated for aesthetic or functional factors (Table 1).<sup>4</sup> Currently, there are several options

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**Table-1:** Indications of bone augmentation.

#### In Aesthetic Areas

- Deficient soft tissue on the buccal aspect
- Bone loss >2 mm horizontally
- Bone loss >50% buccally
- Basal bone less than 3 mm

#### In Non-Aesthetic Areas

- Absence of buccal bone
- Horizontal bone loss greater than 3 mm
- Apical bone less than 3 mm
- Loss of septal bone

#### Functional Indications

- Close proximity to vital structures (such as maxillary sinus, nasal floor)
- Increased risk of buccal bone resorption

available for bone augmentation, including guided bone regeneration (GBR), particulate or onlay bone grafts (with or without membranes), distraction osteogenesis, and ridge splitting.<sup>2</sup> There is considerable evidence for the use of GBR in dehiscence or fenestration defects. However, disadvantages, such as wound dehiscence, membrane exposure and soft tissue complications, have been reported.<sup>5</sup> For larger bone defects, autogenous bone grafts are considered the gold standard due to their osseointegrative and osseo-conductive potential. However, they have the disadvantages of donor site morbidity and unpredictable graft resorption.<sup>4</sup> For vertical defects, distraction osteogenesis can provide a gain of 5-9.9mm, but additional grafting may be required and defects in bone formation and fracture of basal bone have been reported.<sup>6</sup> For horizontal augmentation of a narrow ridge <4mm wide, split ridge technique can be used. However, it may result in the fracture of buccal plate, lack of osseointegration and infections.<sup>4,7</sup>

Regarding the stages of surgical intervention, alveolar augmentation techniques can be performed as a two-staged procedure, where the augmented bone is left to heal and a dental implant is placed after 2-6 months, called the Branemark Protocol.<sup>8-10</sup> For vertical defects of >4.7mm, or horizontal bone of <3.5mm, a two-stage intervention would be preferred.<sup>4</sup> Despite its favourable outcome, this technique prolongs treatment time and increases surgical interventions, which concerns both the patient and the practitioner.<sup>10</sup> An intriguing alternative is to place the implant simultaneously with bone augmentation as a

single-stage technique which saves time and reduces surgical intervention.<sup>11</sup> Additionally, it immediately restores aesthetics through temporisation and conserves soft tissue.<sup>8,9,11</sup> Despite these advantages, the technique has limited indications.<sup>4</sup> It can only be used to restore a dehiscence or fenestration defect and vertical defects of up to 4.1mm.<sup>4</sup>

The concern of delaying implant placement in larger defects up to 6mm have compelled clinicians to explore alternatives. Hence, the bone ring technique (BRT) was introduced with the intention of three-dimensional (3D) bone augmentation with simultaneous implant placement in both maxilla and mandible. A ring-shaped bone is placed in the socket, which is secured by an implant placed through the ring.<sup>12</sup> The BRT provides a 3D augmentation of bone defects. Placement of the implant through the ring stabilizes the bone ring, and the ring, in turn, enhances the primary stability of the implant. The current concepts surrounding bone augmentation in both one-stage and two-stage techniques need to be grasped as they provide the context for understanding the BRT.

BRT was introduced to shorten overall treatment time.<sup>13</sup> The historically followed Branemark protocol was to debride the affected site after extraction to allow healing.<sup>14</sup> With further progress, sinus augmentation was introduced, but to avoid additional augmentation procedures, the use of mini-implants or tilted dental implants was also advocated.<sup>15,16-18</sup> The bone in the shape of a ring for the augmentation of defective sockets was used after modifying the original technique by Watzak et al,<sup>19</sup> who was the first to use autologous bone from the chin for the bony closure of oro-antral fistulas.<sup>19</sup> These modified bone rings augment the defective sockets with simultaneous implant placement. This technique proved successful in bone augmentation and implant integration.<sup>15,20</sup> With the advent of the BRT, clinicians were able to place implants along with the graft in a single stage. However, as with any other technique, careful case selection is crucial for successful outcomes. The following factors are considered as pre-requisites for using the BRT:<sup>13,18,20</sup> There must be 3-4 mm of residual bone to provide primary stability for a dental implant; there must be 1-1.5mm of native bone between the bone ring and adjacent implant/tooth; the recipient site must provide as many vital cells as possible in close contact with the spongy aspect of the augmented bone ring; the bone ring must be rigid and completely immobile; the implant must be correctly positioned for a successful prosthodontic rehabilitation; the wound closure must be definitive, without any tension on the tissue.

Bone rings can either be autogenous or allogenic in nature.

Irrespective of its origin, there are three techniques to secure the bone ring.<sup>21</sup> Further clinical application of all the three techniques is still needed to assess long-term outcome and establish a consensus.<sup>21</sup> The three techniques are: customized press fit technique, osteosynthesis screws (Streckbein approach), and dental implant (Giesenhagen approach).

#### **Customised Press Fit technique**

This technique utilizes a hollow diamond coated drill.<sup>21</sup> A twin-drill principle is followed which uses a bigger drill for obtaining the donor ring and a smaller drill for the recipient site.<sup>21</sup> This results in a snug fit of the bone ring in the recipient bed, without any need of further fixation.<sup>21</sup>

#### **Osteosynthesis screws (Streckbein approach)**

This method is opted for when severe bone loss is present and a customized press fit cannot be achieved.<sup>12</sup> The additional osteosynthesis material is the hamper of the technique.<sup>12</sup> Screws made of titanium or stainless steel can be used with a 1.3-2mm diameter and 6-18mm length.<sup>22</sup> This technique requires a second-stage surgery to remove the fixation screws.<sup>22</sup>

#### **Dental implant (Giesenhagen approach)**

This is the appropriate technique and can be chosen when there is sufficient bony bed for immediate implantation.<sup>12</sup> It provides vertical bone augmentation with maximum anchorage.<sup>12</sup> This is more time-saving than Streckbein approach as it does not require additional surgical procedure.<sup>12</sup>

#### **Autogenous Bone Ring**

Bernhard et al. were the first to use autogenous bone ring with simultaneous implant placement.<sup>12</sup> Bone can be harvested from extra-oral and intra-oral sites.<sup>23</sup> Intra-oral sites from where graft can be harvested are either chin, palate, maxillary tuberosity or the retromolar area. For larger bone defects, extra-oral harvesting is done from the cranium, iliac crest, tibial metaphysis or ribs.<sup>23</sup> The most common distant donor site utilized by maxillofacial surgeons is the iliac crest.<sup>23</sup> It is important to note that the extra-oral sites mentioned are endochondral bones, which are associated with higher resorption rates than intra-oral sites which are intramembranous in origin.<sup>24</sup> Furthermore, extra-oral harvesting mostly requires general anaesthesia, hospitalisation and has the disadvantage of donor site morbidity.<sup>23</sup> Autogenous cortico-cancellous chin bone grafts have been used successfully for the augmentation of localised alveolar defects up to 6mm in horizontal and vertical dimensions.<sup>25</sup> It contains a variety of vital cells and growth factors that have osteo-inductive, osteo-conductive and osteogenic potential.<sup>22</sup> They also give the added

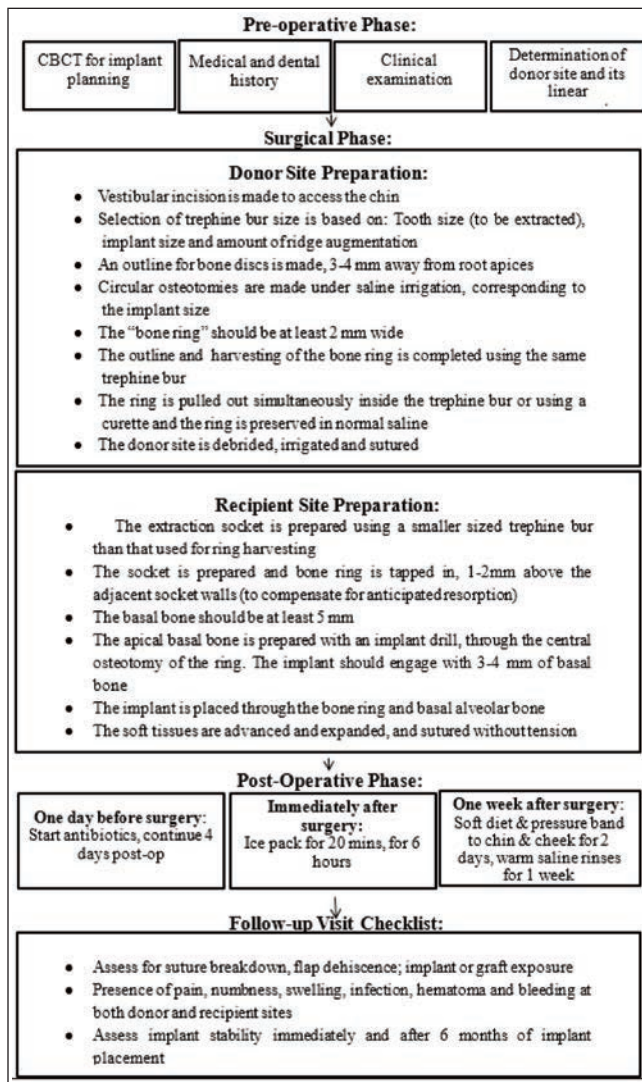


Figure-1: Treatment phases for autogenous bone ring technique (BRT).

\*Allogeneous BRT does not require donor site preparation

benefit of volume enhancement which helps maintain soft tissue contour.<sup>26</sup>

There is a detailed surgical protocol of placing autogenous bone ring (Figures 1,2).<sup>27,28</sup>

Table-2: Indications and contra-indications for the bone ring technique (BRT).<sup>43,45</sup>

Indications
Large bone defects (1-walled, 2-walled, 3-walled and 4-walled defects)
Vertical maxillary sinus grafting
Bone defects that cannot be repaired with particulate grafting
Alveolar ridge augmentation
Contra-Indications
Parallel walled crest
Insufficient residual alveolar bone width (narrow ridge less than 4 mm)
Less than 1 mm of bone height adjacent to the maxillary sinus

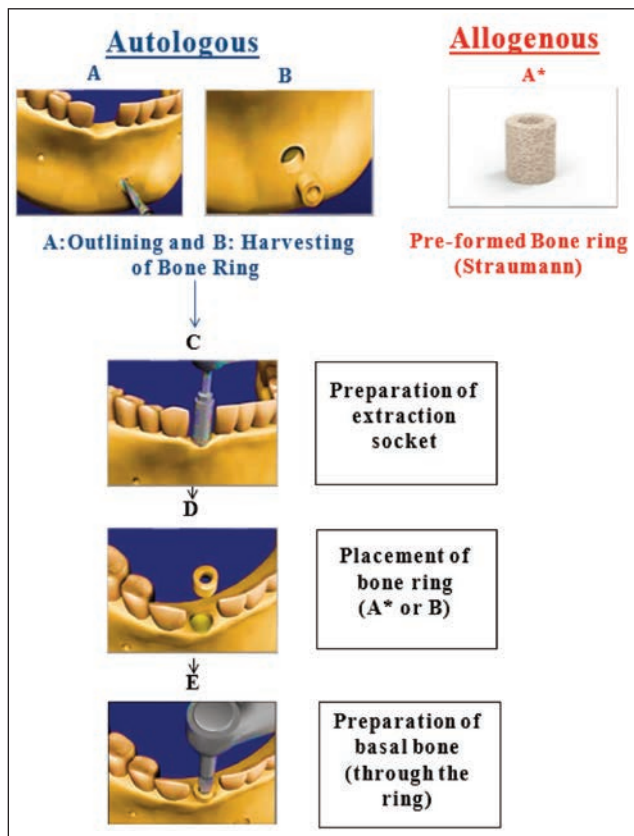


Figure-2: Diagrammatic representation of bone ring technique (BRT).

### Allogenic Bone Ring

The allogenic bone ring technique utilises a preformed cylindrical bone block that is anchored to the recipient site in one step by means of an implant.<sup>18</sup> The basis of this technique is to avoid a second surgical donor site to obtain the graft. This makes the procedure less invasive and increases the patients' comfort without compromising the prognostic and aesthetic outcome. It also reduces the overall surgical time and is less technique-sensitive. Large bony defects were previously reconstructed with a two-stage approach, but the bone ring is a good alternative and can be successful in most defects including four, three, two or one walled defect as well as vertical or sinus augmentation.<sup>18</sup> It is recommended to place the bone ring and implant at least 6 weeks after the extraction of hopeless teeth. This provides a greater amount of keratinised tissue around the surgical site, leading to tension-free closure.<sup>18</sup> It helps to consider the distance of implant from adjacent teeth and anatomical landmarks for papilla fill-in and damage to the nerve respectively, thus avoiding any unpleasant outcome.<sup>18</sup>

### Discussion

The success of implant placement is based on the primary stability, therefore, all implants within bone ring complex

should have adequate primary stability at the time of implant placement.<sup>29</sup> Optimal chances of success are offered by using a two-point stabilization of the bone graft.<sup>29</sup> The first point of stabilization is to alter the shape of the bone cylinder according to the defect, whereas the second stabilization point is provided by fixation of the ring with an implant.<sup>29</sup> However, it can also be advantageous in cases where there is inadequate bone at the base of the socket to anchor the implant.<sup>29</sup> The available literature evaluates the success and survival of this technique, and, additionally, clinical symptoms along with radiographic bone changes have also been reported.

A study by Chen et al. also considered the aesthetic outcomes, using the mean White Esthetic Score/Pink Esthetic Scores (WES/PES). The authors reported the mean WES/PES to be 17.6, which implies excellent aesthetic results.<sup>30</sup> However, the mean bone-gain (BG) or bone-loss (BL) around the implant was the most commonly assessed outcome in most studies (Table 3).<sup>15,20,27,31-36</sup> At 3 years, the horizontal BL has been reported to be as low as  $0.21\pm 0.13$ mm by Chen et al., whereas Ding et al. have reported buccal BL of  $1.46\pm 0.03$ mm after 1 year.<sup>15</sup> Yuan et al. compared the use of autologous bone rings with the tent pole technique in deficient maxilla and found that the BRT showed improved horizontal and vertical bone mass

**Table-3:** Characteristics of clinical studies using bone ring technique (BRT).

Study (year); Study Design	No. of Patients (P); Implants (I)	Implant placement; Augmentation Protocol	Follow-up time	Outcomes: Bone Gain (BG); Bone Loss (BL)
Chen et al. 2023 <sup>30</sup> Retrospective, single arm	P=15, I=15	Single stage placement, BRT autograft	3 years	- Vertical BG: 5.55(0.87) mm - Horizontal BG: 4.73(0.70) mm - Success & survival rate: 100 % - Complication rate: 6.67%
Yawale et al.2022 <sup>46</sup> Longitudinal study	P=15, I=16	Two staged placement; BRT autograft	6 months	- Mesial BL: 1.22 mm - Distal ML: 1.17 mm - Success rate: 93.7 %
Ding et al. 2021 <sup>15</sup> Retrospective, single-arm	P=11, I=12	Two staged placement; BRT xenograft	1 year	- Success & survival rate: 100 % - Buccal BL: 1.46(0.38) mm
Yuan et al. 2021 <sup>31</sup> Retrospective, double-arm	P=30, I=30, TP=15, BRT=15	Two staged placement - Group 1: BRT Autograft (maxilla) - Group 2: Tent Pole Technique (TP)	6 months	- Horizontal BG: Greater BG in BRT ( $p < 0.05$ )
Wychowsky et al. 2020 <sup>32</sup> Non-RCT	P=30, I=60	- Group 1: single stage (BRT autograft (chin) and implant) - Group 2: Xenograft tunnel & delayed implant (XG)	2 years	- Success & survival rate: o BRT: 86.66% o XG: 96.66% - BG (BRT): 4.3 (1.3) mm - BG (XG): 4.4 (1.5) mm - Implant stability was greater for BRT ( $p < 0.005$ )
Yuce et al. 2019 <sup>20</sup> Longitudinal	P=8, I=12	Single stage placement, BRT autograft (chin)	6 months	- Success rate: 100 % - Failed Implants: n=1
Sindel et al. 2018 <sup>33</sup> Longitudinal	P=10, I=10	Single stage placement, BRT autograft (chin)	24.3 months	- Mean marginal bone loss: 1.77 mm - Success rate: 90%
Chandra et al. 2019 <sup>33</sup> Non-RCT	P=34, I=34	Two staged technique - Group 1: BRT autograft - Group 2: Autologous growth factor(AGF)	9 months	- BG (BRT): o Buccal: 3.09 mm o Lingual: 3.31 mm - BG (AGF): o Buccal: 1.90 mm o Lingual: 1.99 mm - Success rate: o BRT: 88.23% o AGF: 100% - BRT group had greater bone density ( $p=0.016$ ), mineralization ( $p \leq .001$ ) and implant stability ( $p = 0.034$ )
Nord et al. 2019 <sup>35</sup> Longitudinal	P=51, I=81	Single stage placement, BRT allograft	1 year	- Success rate: 97.5 % - BL (vertical): 0.43 mm - Graft resorption rate: 8.6(8.3) mm after one year
Omara et al. 2016 <sup>27</sup> Longitudinal	P=10, I=12	Immediate implant; BRT autograft (chin)	6 months	- BG: 0.26(0.87) mm
Giraddi et al. 2016 <sup>36</sup> Longitudinal	P=14, I=15	Single stage placement, BRT autograft (chin)	9 months	- BG Mesial: 3.70(1.10) mm - BG Distal: 3.69 (1.10) mm - Success rate: 93.33%

at 6-month follow-up.<sup>31</sup> Wychowansky et al. compared the use of BRT with xenograft tunnel grafts. The authors stated that autogenous BRT may be more suitable for patients who were systemically healthy, considering the reduced time and cost of treatment. They suggested that since there were no significant differences in terms of bone augmentation, the vertical tunnel augmentation technique may provide a more conservative alternative in immunocompromised patients.<sup>32</sup> A high success rate was noted by several studies.<sup>27,32-36</sup>

Generally, immediate implant placement is contraindicated in extraction sockets with either endodontic or periodontal infections, as evidence indicates infections may predispose implant infection or failure. However, a longitudinal study by Omara et al. employed immediate implant placement with autogenous bone ring placement and reported favourable outcomes at 6-month follow-up.<sup>27</sup> Regarding single-stage versus two-stage surgery, Nakahara et al. compared these two stages using BRT, and concluded that both techniques yielded similar results and could be considered equally efficient, but a single-stage technique to shorten treatment time was recommended.<sup>37</sup> Similarly, Tekin et al. preferred one-stage approach to reduce treatment time,<sup>29</sup> whereas Kaufman et al. favoured a two-stage approach.<sup>38</sup> It is noteworthy that there are limited studies comparing the outcomes of one-stage versus two-stage augmentation, and further studies are required to determine any additional benefits of two-stage surgery.

Considering the choice of graft material, favourable results have been noted by autografts, allografts and xenografts. Nord et al. concluded the allograft bone ring exhibited favourable outcome on annual follow-up in cases with large vertical defects.<sup>35</sup> Chandra et al. compared the use of autogenous bone rings with autologous growth factors.<sup>34</sup> They concluded that the autogenous bone ring procedure showed additional benefits over autologous growth factor-enriched bone graft.<sup>34</sup> Benlidayi et al. compared allogeneous and autogenous bone rings in surgically created bone defects in a sheep model<sup>39</sup> and concluded that allograft bone ring provides a favourable outcome in augmentation of surgically created vertical bone defects around implants after 8 months of healing.<sup>39</sup> Ozgul et al. compared the stress distribution along the alveolar bone following the allogenic and autogenous bone ring<sup>40</sup> and concluded that although autogenous bone rings had lower stress values, allogenic bone rings showed better stress distribution and may be preferred under the right indications.<sup>40</sup> With respect to morbidity of donor site, it has been stated that postoperative paresthesia takes a year to resolve.<sup>41</sup> At radiographic examination, the donor site displayed adequate re-mineralisation despite leaving a radiologic

concavity in the majority of cases. Bone healing after chin graft harvesting did not regenerate to the preoperative level.<sup>42</sup> These studies suggest that the allogenic bone ring may have several advantages over autograft techniques.

Several authors have reported that controlling the position of the dental implant relative to the bone ring can be challenging, particularly when replacing maxillary anterior teeth.<sup>43</sup> Since the position of the dental implant dictates the final prosthetic and aesthetic outcome, implant positioning is of critical importance in the aesthetic zone. Considering this, Simpson et al. described a digital workflow where the position of the allogenic bone ring was predetermined using a 3D bone ring analogue on computer-aided design (CAD) software.<sup>44</sup> The virtual bone ring and dental implant were then virtually positioned using the implant planning software and 3D printed surgical guides were created to position the bone ring and the dental implant. However, the authors reported that the dental implant had an angular deviation of 6.1° from the planned implant position. Although this lies within the acceptable range, it is likely that using completely guided systems can offer additional advantages in improving the accuracy of implant placement.<sup>44</sup> Moreover, the indications and contraindications for BRT are summarized in Table 2.<sup>43,45</sup>

Despite the growing evidence on the use of BRT, it is noteworthy that the available data remains heterogeneous due to the differences in outcomes that have been reported. Future randomized controlled trials with standardized protocols and outcome assessment can allow for a better understanding regarding the use of BRT.

## Conclusions

The available literature regarding the bone ring technique indicates that it is an effective treatment modality for severely resorbed alveolar ridges. However, the outcomes reported remain heterogeneous and require further standardization. Future studies should consider changes in bone dimensions buccolingually, along with marginal BL with longer follow-up times. Moreover, randomized controlled trials assessing different grafting protocols, like autograft versus allograft, are required to develop more stringent guidelines on the use of this technique.

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**Author Contribution:**

SJ: Substantial contributions to the conception or design of the work.

MK: Substantial contributions to the conception or design of the work, acquisition, analysis, or interpretation of data, drafting, and revision.

RG: Final approval, agreement to be accountable for all aspects of the work.