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The influence of cortical bone perforation on guided bone regeneration in humans

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Abstract. The purpose of this study was to evaluate the effect of cortical bone perforation on angiogenesis and osteogenesis of the augmented ridge in guided bone regeneration. Eighteen patients who had osseous defects in the mandible were selected. In the test group ($n = 9$), alveolar cortical bone in the area of regeneration was perforated. No decortication was performed in the control group ($n = 9$). Subsequently, defects were augmented by guided bone regeneration using resorbable membrane and bovine bone. After a healing period of 7 months, trephine cores were harvested for histological and histomorphometric analysis of the grafted areas. Histomorphometry demonstrated that the amount of newly formed bone in the test group (27.8%) was greater than that in the control group (25.3%), but the difference was not statistically significant ($P = 0.13$). However, the mean number of microvessels in the test group was significantly higher than that in the control group ($P = 0.01$). This study found that cortical bone perforation favourably affects the amount of new bone formation in the grafted sites after 7 months of healing. Cortical bone perforation significantly increase number of new vessels (angiogenesis) of the regenerated bone. Further randomized clinical trials are required to confirm these results.

Key words: guided bone regeneration; GBR; decortication; bone perforation; angiogenesis; osteogenesis; histomorphometric; histology.

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A sufficient amount of bone surrounding implants is essential to obtain a satisfactory treatment outcome in the long term.[1] A deficiency of the alveolar ridge resulting from a trauma, pathology, or congenital defect, may impede implant placement.[2] The principles of guided bone regeneration (GBR) have been used for many years to augment the bone height and/or width and provide clinicians with an adequate amount of bone for implant placement.[3,4] Various clinical studies have shown bone regeneration within or beyond the confines of the original skeletal boundary by creating space for new bone formation and excluding soft tissue from invasion into the space.[5,6]

The intramarrow penetration of cortical bone may affect the quality of regenerated bone by facilitating the migration of osteoprogenitor cells from the bone marrow into the isolated space created.[7] Previous studies have used cortical bone decortication in different clinical conditions, such as periodontal osseous defects and alveolar ridge augmentation.[8–10] However, perforation of the cortical bone prior to GBR is a controversial subject. Lee et al. showed that intramarrow perforation may improve the amount of newly formed bone and accelerate angiogenesis.[11] In contrast, there are some studies that have shown no beneficial effect for

perforation of the cortical bone prior to GBR.[12–14]

The question of whether such perforations would have any effect on the quality of regenerated bone histologically in humans has not been addressed. This study evaluated the effect of intramarrow penetration on regenerated bone histologically in humans. The purpose of this study was to evaluate the effect of cortical bone decortication on the angiogenesis and osteogenesis of the augmented ridge in GBR.

Materials and methods

Eighteen patients (eight men and 10 women) who required dental implants in areas with mandibular osseous defects were selected. The patients had a median age of 52 years (age range 25–72 years) and were in good general health. All of the patients presented a partially edentulous mandible with either an extended or single tooth gap. Subjects were assigned to one of two groups: test patients ($n = 9$) received perforation of the recipient bed; control patients ($n = 9$) had no perforation of the recipient bed prior to GBR.

The inclusion criterion was the presence of an atrophic mandibular ridge with a buccolingual width of between 2 mm and 5 mm, as measured on serial sections of an axial computed tomography scan. Patients with diabetes, osteoporosis, or other metabolic disorders, smokers, pregnant patients, and patients who had any systemic or local factors that would inhibit a normal wound healing process were excluded. All of the patients volunteered to participate in the study and informed consent was obtained from each of them. The patients were informed that a biopsy specimen would be taken from the grafted site at the time of implant placement with no untoward effect on implant osseointegration. All procedures and materials were approved by the local ethics committee and the institutional board of research. The principles of the Declaration of Helsinki were followed in this study.

Surgical procedure

The patients were prescribed antibiotic prophylaxis (1 g of amoxicillin given orally 1 h preoperatively and then every 8 h after the procedure for 7 days). Intrasulcular and crestal incisions were used to elevate a full thickness periosteal flap and expose the recipient bone. In the areas with an existing tooth adjacent to the osseous defect, the intrasulcular incision was extended two teeth mesial or distal to the defect.

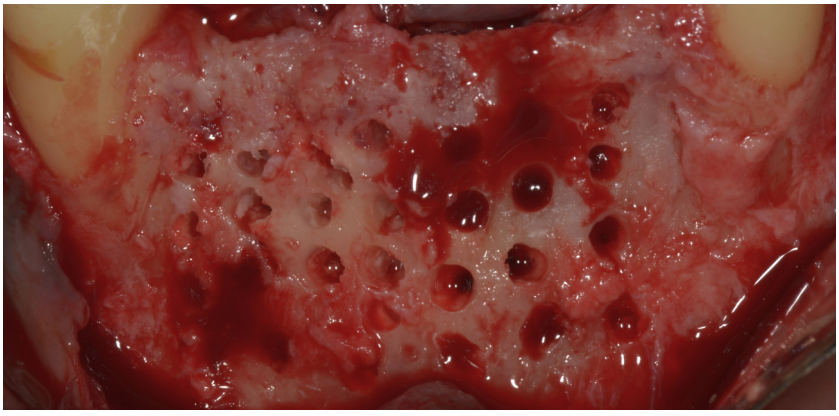

Fig. 1. Cortical bone perforations were carried out inside the area of the bone augmentation.

Following flap elevation, the alveolar bone ridge was examined carefully and the implant site was identified using a stent. All of the cases had a sufficient amount of vertical bone height and only the orofacial bone width at the prospective implant site needed to be augmented.

In the test group patients, the alveolar cortical bone in the area of regeneration was perforated using a number 2 high-speed round bur, under generous irrigation with 0.9% saline solution, to allow access of the cells from the bone marrow to the augmented site (Fig. 1). No decortication of the cortical bone was performed in the control group patients. Subsequently, a resorbable collagen membrane was placed and stabilized with fixation pins (Ace Surgical, Brockton, MA, USA) at the apical part of the defect. Particles (particle size 250–1000 μm) of cancellous deproteinized bovine bone mineral (Bio-Oss; Geistlich AG, Wolhusen, Switzerland) were placed in the defect area and covered by the membrane. The ridge was augmented to a size sufficient for standard implant placement. A periosteal releasing incision was performed at the apical portion of the flap; tension-free primary closure was achieved and the flap was sutured with resorbable suture material (Vicryl, Ethicon, Somerville, NJ, USA).

Postoperatively, the patients received analgesic and anti-inflammatory medication (ibuprofen 600 mg) for 3 days and were instructed to rinse with 0.12% chlorhexidine digluconate oral rinse twice daily for 2 weeks. Postoperative examination and suture removal were performed after 14 days. If needed, the temporary partial dentures were adjusted to avoid trauma to the surgical area.

After a 7-month healing period (mean 7.4 months), prior to implant placement, the alveolar ridge was exposed and the augmented site visualized. Bone core samples (3.5 mm in diameter and 10 mm in length) were obtained from within the boundaries of the augmented site using a trephine drill, under copious irrigation, without compromising implant placement. Dental implants (Straumann AG, Waldenburg, Switzerland) were placed according to standard protocols in a prosthetically ideal position and the flap repositioned and sutured; 29 implants were placed in the 18 patients. All biopsy specimens were placed in 10% neutral buffered formalin for 10 days to fix the dissected block sections.

Histological preparation

The bone specimens were cleared with xylene and embedded in paraffin. Sections 4 μm thick were cut longitudinally using a Jung K microtome (Leica microtome type sm2500s; Leica, Wetzlar, Germany). The prepared slices were stained with haematoxylin and eosin (H&E) and observed in normal transmitted light under a microscope (Carl Zeiss, Oberkochen, Germany). Bone vitality, foreign body reaction, and the number of microvessels were assessed.

Histomorphometry

The histomorphometric analysis was performed by digitizing the images from the microscope with a camera (Olympus BX50; Olympus Optical Co., Tokyo, Japan) and a frame grabber. The images from each area of the biopsy core were obtained and analysed using image analysis software (ImageLab 2000; Softium, Sao Paulo, Brazil) to calculate the thickness of the bone trabeculae (μm) and the percentages of residual graft particles (RG), newly formed bone (NB), and soft