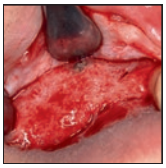
Cortical Bone Repositioning Technique for Horizontal Alveolar Bone Augmentation: A Case Series



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The objective of this study was to present a novel procedure for cortical bone repositioning (CBR) that maintains a secure space under the periosteum by replacement of the lateral cortex via fixation, employing titanium screws. Seven systemically healthy patients presenting with horizontal alveolar bone defects in radiographs and CT images were enrolled for CBR technique for horizontal alveolar bone augmentation. A lateral cortical bone block was cut in the defects and freed from the original bony surface. A screw was inserted into the block, and the block was placed laterally to allow fixation. The block was checked for adequate stability, and the flap was closed after creation of periosteal releasing incisions to ensure tension-free closure. There were no complications, and 16 implants were placed uneventfully. Preoperative bone width in the defect area was 3.28 mm; the postoperative 4-month bone width in the same area was 6.46 mm. The mean implant stability quotient (ISQ) at placement was 68. At the secondary operation for changing to a healing abutment, the mean ISQ was 72. All patients were functionally and esthetically rehabilitated with implant-supported dentures. CBR technique is a simple procedure without the use of any biomaterials or devices. The main advantage of this technique in comparison to autogenous grafts is the lack of donor site issues. This technique has the possibility of inducing the patient's regenerative ability for bone healing.
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Following tooth loss, deficiencies in alveolar ridge bone height and width may limit the use of dental implants. Clinically, the greatest loss of alveolar ridge is usually in the horizontal dimension.[1] Recently, ridge augmentation has been adopted for functional and esthetic implant-supported restoration of an atrophic, narrow alveolar process. Bone grafting with autogenous bone, guided bone regeneration (GBR), and ridge expansion techniques have been used for this purpose.[2–4] GBR combines application of autografts and membranes and is a predictable surgical procedure for lateral ridge bone augmentation that results in enlargement of the alveolar crest in partially edentulous patients. However, these procedures have disadvantages, such as the need for surgical intervention to harvest bone, unpredictable bone resorption, and difficulty with soft tissue coverage, resulting in a risk of wound dehiscence. In 1996, alveolar distraction osteogenesis (DO) was introduced as an effective new technique for ridge augmentation,[5] and the vertical alveolar DO technique is now applied widely to correct alveolar ridge defects or atrophy. The advantages of DO over bone grafts and GBR include the absence of a donor site and simultaneous lengthening of the surrounding soft tissues.

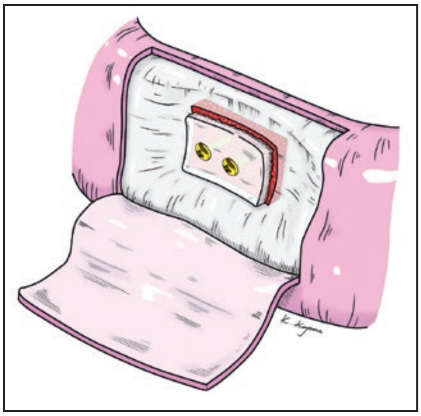

Fig 1 *Schematic image of cortical bone repositioning.*

Previously, it was shown clinically and experimentally that the transport segment serves as a space maker when the DO technique is used; it is most important to maintain a secure space under the periosteal point to allow successful bone regeneration.[6–8] Lethaus et al[9] found no significant difference between static and dynamic activation when GBR was performed in a pig model. Several static bone augmentation methods for dental implant therapy have been developed. The split crest is the most popular method; the crestal bone is split to create a width sufficient for implantation.[10,11] This method can be used to correct horizontal defects in the crestal region; fixation of the split bone is usually not necessary. Sometimes, the crestal bone is resorbed at the edge of the split area. Another static method is the shell technique, which creates a space under the periosteum using an autogenous bone block or a biomaterial.[12,13]

The present article describes a novel procedure that maintains a secure space under the periosteum by replacement of the lateral cortex via fixation, employing titanium screws. This cortical bone repositioning (CBR) technique avoids donor site morbidity, is a single operation (thus, there is no postoperative activation phase), and uses minimal amounts of materials to encourage regeneration of a horizontal alveolar bone defect (Fig 1).

Materials and Methods

Inclusion criteria were adequate oral hygiene, absence of local inflammation or mucosal disease, and adequate vertical height for implant insertion. Exclusion criteria included severe clenching or bruxism, drug or alcohol abuse, nicotine abuse, diabetes, history of radiation or chemotherapy (especially with a molecularly targeted drug), immunocompromised status, and general conditions for surgical procedures. The mean age of the patients (one man, six women) was 45.1 years (range: 24 to 72 years). A diagnostic stent was made and used to plan the fixed dental prosthesis prior to data collection via general radiograph and computed tomography (CT). A horizontal alveolar bone defect was observed in the cases: the vertical height was adequate for implant insertion, and the buccal and lingual/palatal cortices were clearly observed. Thus, these structures contained thin cancellous bony areas evident on CT images. Perioperatively, all patients received amoxicillin (Sawacillin, Astellas Pharma) 750 mg/day or cefdinir (Cefzon, Astellas Phama) 300 mg/day for at least 3 days. This clinical evaluation was approved by the ethics committee for research in humans at the Tohoku University Postgraduate School of Dentistry.

Surgical Procedure

Midcrestal incisions were made, followed by sulcular incisions with or without vertical incisions on the neighboring teeth. Full-thickness flaps were raised, and the defect areas were exposed to allow insertion of surgical instruments.

Bone blocks (minimum height 6 mm) were designed for placement in the defects, and an ultrasonic bone-cutting device or a small-fissure burr was used to cut the lateral cortex only. Prior to block mobilization, a pilot hole for screw insertion was drilled, but only in the lateral cortex. A self-tapping miniscrew was inserted and advanced until it touched the lingual/palatal cortex. After confirmation that the lateral bone block was freed from the original bony surface and that the position was adequate, the screw was removed and the lingual cortex was drilled out to a diameter identical to that of the lateral hole. The screw was reinserted into the lateral cortical bone block and the block placed laterally to allow fixation on further screw insertion into the lingual/palatal cortex. After checking that the block was adequately stable, a small amount of particulate autogenous bone taken by bone scraper from the surrounding original surface was placed at the step (not in the gap) between the block and the original surface. In some patients with big steps, or when problems were encountered with the blocks, a resorbable membrane was placed over the block area. The flap was closed after creation of periosteal releasing incisions to ensure tension-free closure (Fig 2).

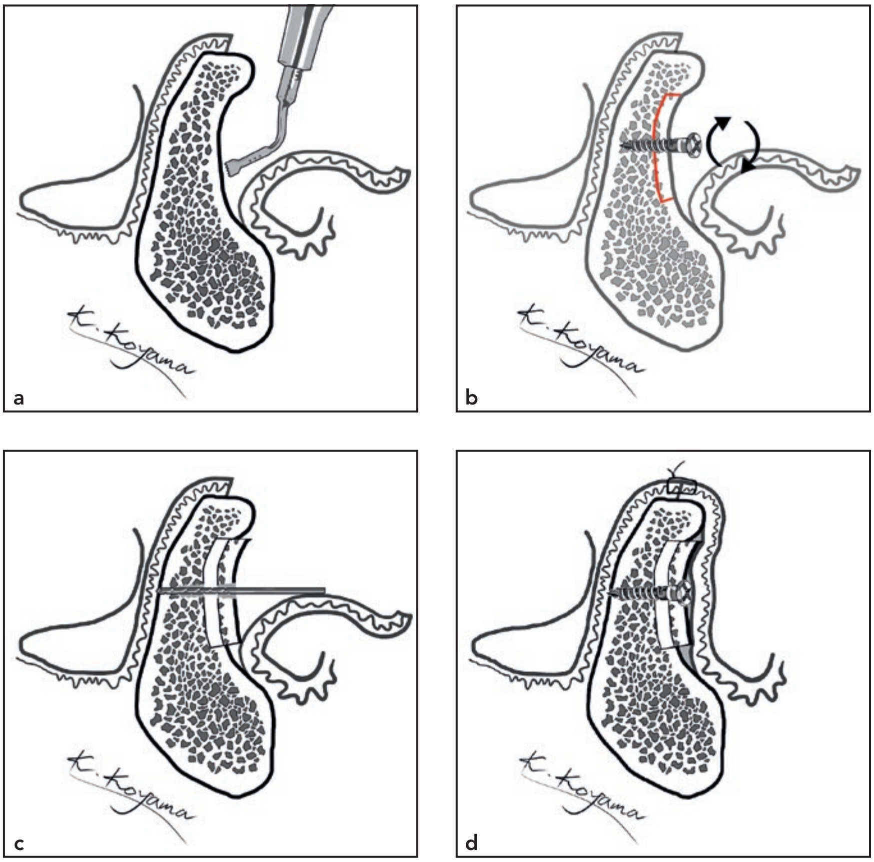

Fig 2 *Surgical technique of cortical bone repositioning.* (a) *Single corticotomy using ultrasonic bone cutting device.* (b) *Drilling to the lateral cortical bone, screw insertion, and mobilization of lateral cortical bone block.* (c) *Screw removal and drilling to lingual/palatal cortical bone.* (d) *Fixation of the block by position screw technique.*

Radiographic Evaluation

Routine radiographic examinations were performed by orthopantomogram and intraoral radiographs preoperatively and at 1, 3, and 6 months postoperative. CT scans were taken preoperatively and at 3 months postoperative.

Resonance Frequency Analysis

Resonance frequency analysis (RFA) was used to provide an objective measure of implant stability. This was carried out with a transducer probe (Mentor Probe II, Osstell) and a standardized abutment (Smartpeg, Integration Diagnostics). The resonance frequency was defined by the amplitude change. The implant stability quotient (ISQ) was determined and described on a scale of 1 to 100. Immediately after implant insertion, the RFA measurement was made for all patients. It was repeated for all patients with nonsubmerged implants during postoperative weeks 16 and 24.

Results

Clinical Observations

All patients underwent the CBR technique for a horizontal defect area (Table 1). In one patient, the cortical bone segment fractured at the time of mobilization from the original position and was divided into two pieces. Each segment was fixed with a titanium miniscrew at a position on the lateral and upper side that partially overlapped the original cortical bone. In three patients with large steps and when problems were encountered with the blocks, a resorbable membrane was placed over the block area. There were no complications such as wound dehiscence, infection, or screw loosening after the surgery, and implants were inserted uneventfully.

Bone Width

Preoperative bone width in the defect area was 3.28 ± 0.39 mm (range: 3.0 to 4.0 mm); the postoperative

Table 1 Distribution of Patient Information, Defect Area, Bone Width Pre- and Postoperation, and Complications

Patient	Age (y)	Sex	Site affected (FDI)	Preoperative bone width (mm)	Postoperative bone width (mm)	Implant timing	Complication
1	25	F	13–14	3.5	7.5	Staged	–
2	52	F	33–34	3.3	7.4	Simultaneous	–
3	72	F	11–21	3.6	7.6	Staged	Bad fracture
4	24	F	13–15	2.8	4.1	Staged	–
	24	F	23–25	3.1	6.5	Staged	–
5	59	F	11–12	3.1	5.8	Simultaneous	–
6	58	F	22	3.0	6.5	Staged	–
7	26	M	12	3.1	6.7	Staged	–

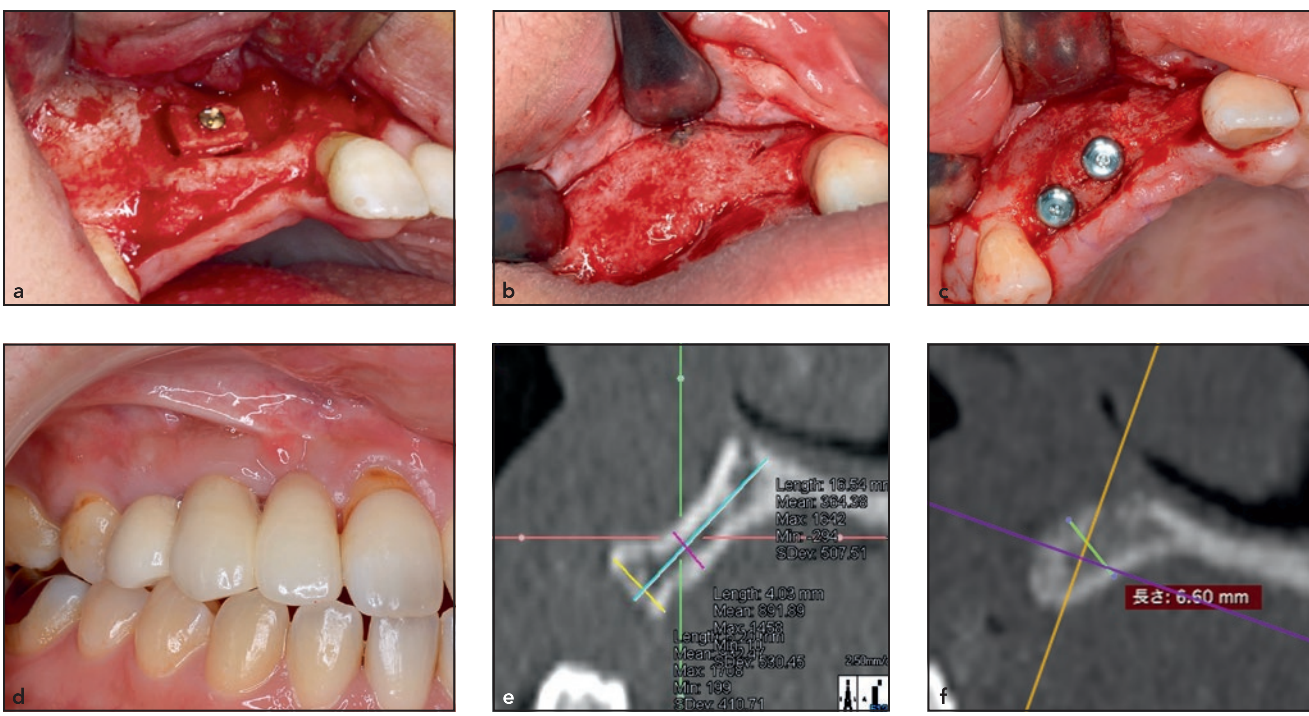

Fig 3 *Intraoral photographs and cone beam computed tomography (CBCT) cross-sectional images (patient 1; cleft lip and palate). (a) Fixation of the block by position screw technique. (b) Raising flap after consolidation period for 4 months. Bone gap was filled with newly formed bone. (c) Two implants were inserted without dehiscence of implant surface. (d) Final prosthesis. (e) Preoperative CBCT cross-sectional image. Horizontal bone atrophy was observed. (f) Postoperative CBCT cross-sectional image. Width of alveolar crest was gained via cortical bone repositioning.*

4-month bone width in the same area was 6.46 ± 1.10 mm (range: 4.1 to 7.6). The gain in bone width was 3.15 ± 3.15 mm (range: 1.3 to 4.0) (Figs 3 and 4).

Implant and Crown Placement

In total, 16 implants were placed in the augmented area: 4 simultaneously with the CBR procedure and 12 after a bone consolidation period of more than 4 months (Table 2). All implants were placed with a two-stage approach, and these second operations were also uneventful.

Table 2 Distribution of Implant Position, Length, Width, Type of Implant, and ISQ Value at First and Second Operations

Patient	Implant position (FDI)	Width (mm)	Length (mm)	Implant type	ISQ at first operation	ISQ at second operation
1	13	3.5	11.5	Nobel Biocare	61	69
	14	3.5	11.5	Nobel Biocare	64	68
2	33	3.5	13	Astra Tech	71	75
	34	3.5	13	Astra Tech	69	74
3	11	3.5	11	Astra Tech	74	75
	21	3.5	11	Astra Tech	72	73
4	13	3.5	11	Astra Tech	66	69
	14	3.5	9	Astra Tech	58	63
	15	4.0	9	Astra Tech	74	79
	23	4.0	11	Astra Tech	77	81
	24	4.0	11	Astra Tech	71	74
	25	4.0	11	Astra Tech	63	71
5	11	3.7	13	Zimmer	46	58
	12	3.7	13	Zimmer	58	75
6	22	3.5	11	Astra Tech	71	77
7	12	3.5	11	Astra Tech	57	75

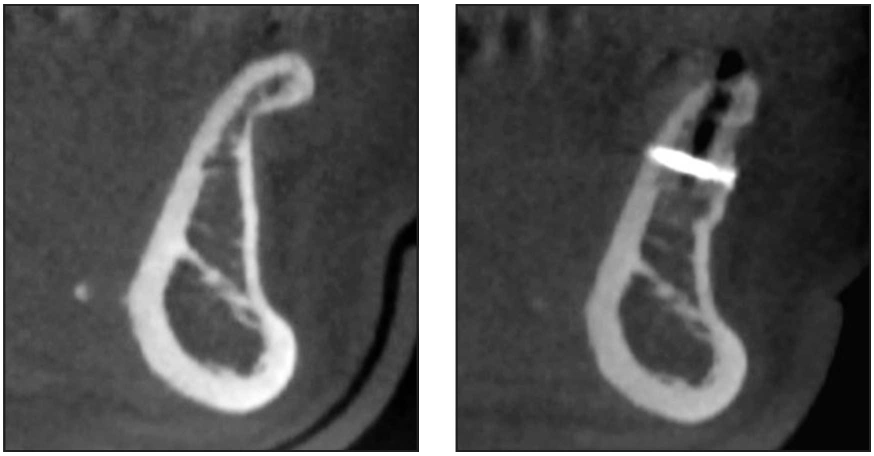

Fig 4 *Cone beam computed tomography cross-sectional images (patient 7).* (a) *Preoperative. Horizontal bone atrophy was observed.* (b) *Postoperative. Two titanium screws were used for fixation of bone block. Width of alveolar crest was gained via cortical bone repositioning.*

Implant lengths varied between 9 and 13 mm, depending on the bone volume. All titanium screws that fixed the cortical bone were removed after the bone consolidation period. All implants were uncovered after 3 to 5 months. Single or splinted crowns were attached after provisional restorations. All patients were fully rehabilitated, functionally and esthetically, with implant-supported dentures. Intraoral radiographs were taken to evaluate the precise fit and the peri-implant bone level, and there were no clinical problems at average follow-up 25.4 months (range: 19 to 31 months) after loading.

RFA

ISQ values are presented in Table 2. Stability measurements at implant insertion had a mean ISQ of 68 ± 8.2 (range: 46 to 77) for all implants. The mean value was 72 ± 5.8 (range: 58 to 81) at the second operation for changing to a healing abutment.

Discussion

Horizontal atrophy of the alveolar region may render implant placement difficult, compromising prosthetic rehabilitation. Various surgical techniques have been developed to solve this problem; these include autogenous or artificial bone grafts and the split crest technique. These conventional procedures have certain disadvantages, including donor site morbidity, unpredictable bone resorption, and difficulties with soft tissue coverage.

DO is an innovative procedure used to avoid donor site morbidity, problems with soft tissue coverage, and limited augmentation.[5] Watzak et al[14] developed a horizontal DO technique using a microbone screw with all of the advantages of DO and no volume limitation. However, disadvantages were also apparent, including the need for daily manual activation and a second operation to remove the device, limitations of the distraction vector, and risk of infection from the activation rod. Previous experimental studies showed that bone regeneration might occur in secure regions under the periosteum. Lethaus et al[9] found no difference in bone formation after performance of dynamic and static procedures in which space was created under a titanium mesh.

CBR is a static procedure: A secure space is created under the periosteum via lateral replacement of a buccal cortical bone block. CBR is a one-stage procedure (postoperative activation is not required), allows full defect coverage with soft tissue, requires minimal materials, can be performed in a single surgical field, lacks donor site morbidity, and is rapid.

The shell technique is similar to CBR. It also creates a space under the periosteum with biomaterials (a bone block or segmented bone) that is fixed with titanium miniplates and screws. An autogenous bone block is still used to create or protect the space under the periosteum. Furthermore, it seems to take time to adjust the bone segment or biomaterial to fit the defect area by grinding or cutting the interference area. The cortical bone block in the CBR technique is made from the defect area, so there is no need to adjust the form to fit the defect area; the bone segment is simply fixed with adequate space between the block and the harvested lingual or palatal cortex.

Conventional grafting is associated with donor site morbidity; the autologous bone is harvested from a remote area.[15,16] The use of allografts and xenografts has been advocated to avoid donor site morbidity. However, such grafts may be associated with infections, resorption after grafting, and additional costs.

Osteosynthesis is a standard method in oral and maxillofacial surgery, especially for open reduction with internal fixation (ORIF), orthognathic surgery, and jaw reconstructive surgery.[17,18] Screw fixation must be rigid to afford adequate strength and stability for mastication; the technique has been used widely for many years. Two forms of screw fixation are available: lag screw and position screw fixation. The position screw technique affords adequate fixation without compression. The bone segment and the original bone must be held in alignment according to the pilot screw hole, and subsequently the screw itself engages both bone substitutes. The interbone gap can be maintained and the length of the gap can be controlled during the screwing procedure. The CBR technique was applied to maintain the lateral cortical bone block laterally against the overlying soft tissue, including the periosteum. This intercortical bone gap may induce bone healing not only inside but surrounding the bone gap between the bone block and original bone surface. Secure fixation is needed to achieve stability; the use of two fixation screws is appropriate to avoid the rotational movement of the block possible with one-screw fixation.

Bone regeneration after application of CBR appears to differ from that after bone grafting. In the grafted area, consolidation of augmentation material involves the formation of a graft-woven bone complex, which is remodeled into lamellar bone and can accept functional loading.[19,20] However, bone healing after DO occurs via callus formation, similar to the fracture-healing process, characterized by overlapping modeling, exhibiting regional acceleration.[21] Regeneration after CBR is similar to bone healing after a fracture; the osteotomized bone block is located laterally and does not overlap the cortical bone.

RFA can provide an objective evaluation of implant stability and evidence for extending implant osseointegration.[22,23] In the present study, the ISQ ranged between 46 and 74 (mean: 68) at implant insertion and between 58 and 81 (mean: 72) at the secondary operation for setting the healing abutment. The value increased in all cases during this period, suggesting that bone integration or remodeling progressed between the CBR part and the surrounding original bone tissue.

An extremely narrow alveolar bone with a small marrow space is at higher risk of cracking or fracturing the cortical bone block at the point of separation from the original bone. Thus, indications for CBR include cases with cancellous bony areas between the lateral and medial cortical bone. Furthermore, the initial stability of the bone block is dependent on adequate screw fixation at the palatal or lingual cortex; poor cortex quality is associated with a risk of fixation failure. It is better to advise the patient to accept conventional grafting when block fixation is unstable.

Conclusions

An advantage of the CBR technique versus autogenous grafts is the lack of donor site issues. The technique has the possibility of inducing the patient's regenerative ability for bone healing. Further clinical and experimental studies are needed to demonstrate the stability and healing process for the treatment of horizontal defects in the alveolar region.

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