CHAPTER 26

Cortical Bone Repositioning Technique

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Introduction

Previously, we showed both clinically and experimentally that the transport segment serves as a space-maker when the distraction osteogenesis (DO) technique is employed; it is most important to maintain a secure space under the periosteal point to allow successful bone regeneration [1–3]. Lethaus et al. found no significant difference between static and dynamic activation when guided bone regeneration was underway in a pig model [4]. 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 [5,6]. This method can be used to correct horizontal defects in the crestal region; fixation of the split bone is not usually necessary. Sometimes, the crestal bone is resorbed at the edge of the split area. Another static method is the "shell technique" that creates a space under the periosteum using an autogenous bone block or a biomaterial [7,8]. In this chapter, we describe our novel procedure, which 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 without any postoperative activation phase), and uses a minimal amount of materials to encourage regeneration of a horizontal alveolar bone defect (Figure 26.1a and b).

Screw fixation

Osteosynthesis is a standard method in oral and maxillofacial surgery, especially for open reduction with internal fixation (ORIF), orthognathic surgery, and jaw reconstructive surgery [9,10]. Screw fixation must be rigid to afford adequate strength and stability for mastication; the technique has been widely used for many years. Two forms of screw fixation are available, lag screw and position screw fixation (Figure 26.2a and b). If the bony contact between the original bony surface and the bone segment is good, the lag screw technique is ideal. Here, the screw hole in the outer cortex or bone segment is reamed to a diameter slightly greater than the outer diameter of the screw, whereas the hole in the inner cortex or original bone is smaller. This difference in diameter creates compression and stability; the outer segment is pushed inward by the screw head. In the bone graft technique, the shape of the bone block is adapted to that of the original bony surface, and bone remodeling may then progress safely because the contact between the segment and original bone is ideal; no space is available for soft tissue insertion. The position screw technique affords adequate fixation without compression. The bone segment and the original bone must be held in alignment as 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.

Indications

With either technique, a diagnostic stent is made and used to plan the fixed dental prosthesis prior to data collection via conventional radiography and computed tomography (CT). A horizontal alveolar bone defect was observed in our present case: 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 that are evident on CT images.

Surgical technique (Figure 26.3a to i)

Generally, mid-crestal incisions are followed by sulcular incisions with/without vertical incisions on the neighboring teeth. Full-thickness flaps are raised and the defect areas are exposed to an extent that allows insertion of surgical instruments. Next, slits are made in the periosteum below the flap to allow tension-free closure.

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

Horizontal Alveolar Ridge Augmentation in Implant Dentistry: A Surgical Manual, First Edition. Edited by Len Tolstunov.

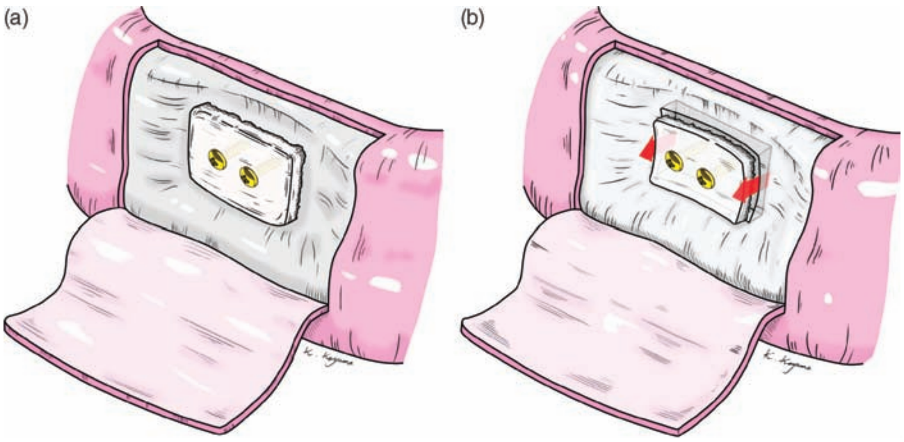

Figure 26.1 (**a**) Block bone graft, (**b**) cortical bone repositioning (CBR).

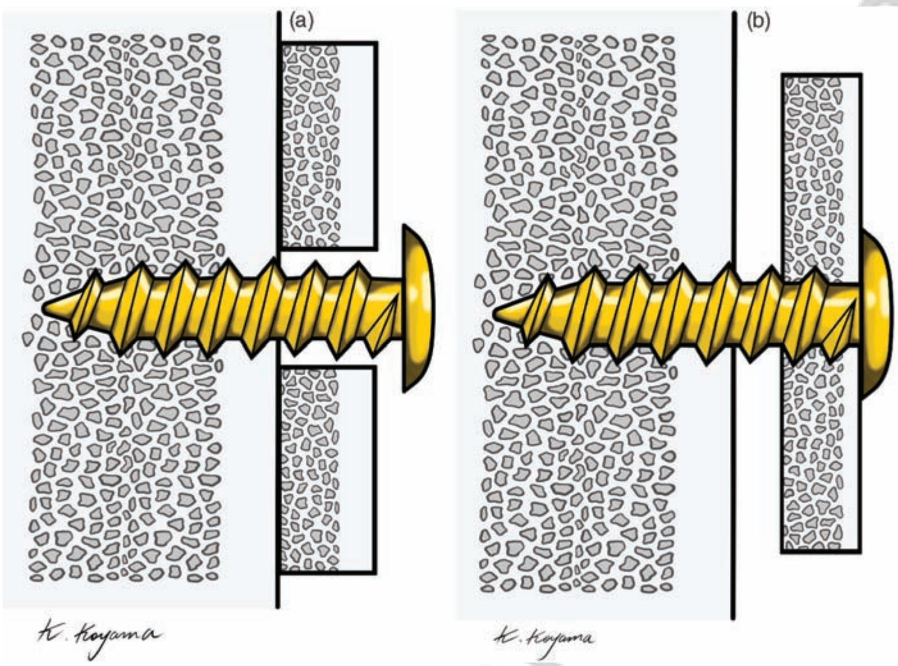

Figure 26.2 Type of screw fixation: (**a**) lag screw, (**b**) position screw.

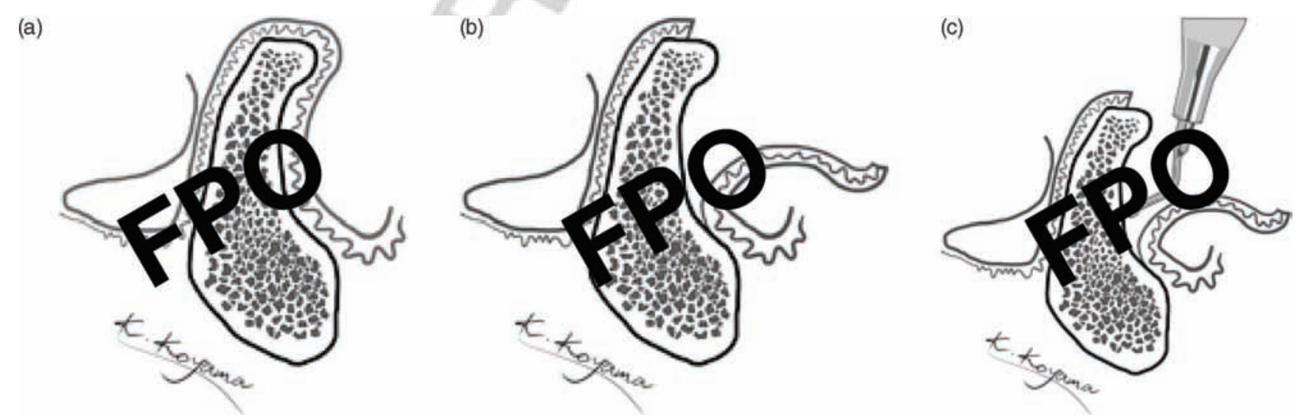

Figure 26.3 Surgical technique of CBR: (**a**) pre-operative condition, (**b**) making a crestal incision and raising flap, (**c**) single corticotomy using an ultrasonic bone-cutting device, (**d**) screw insertion and mobilization of the lateral cortical bone block, (**e**) screw removal and drilling to the lingual cortex, (**f**) lateral repositioning of the cortical bone block, (**g**) flap closure after periosteal releasing incisions, (**h**) after a consolidation period, (**i**) screw removal and implant insertion.

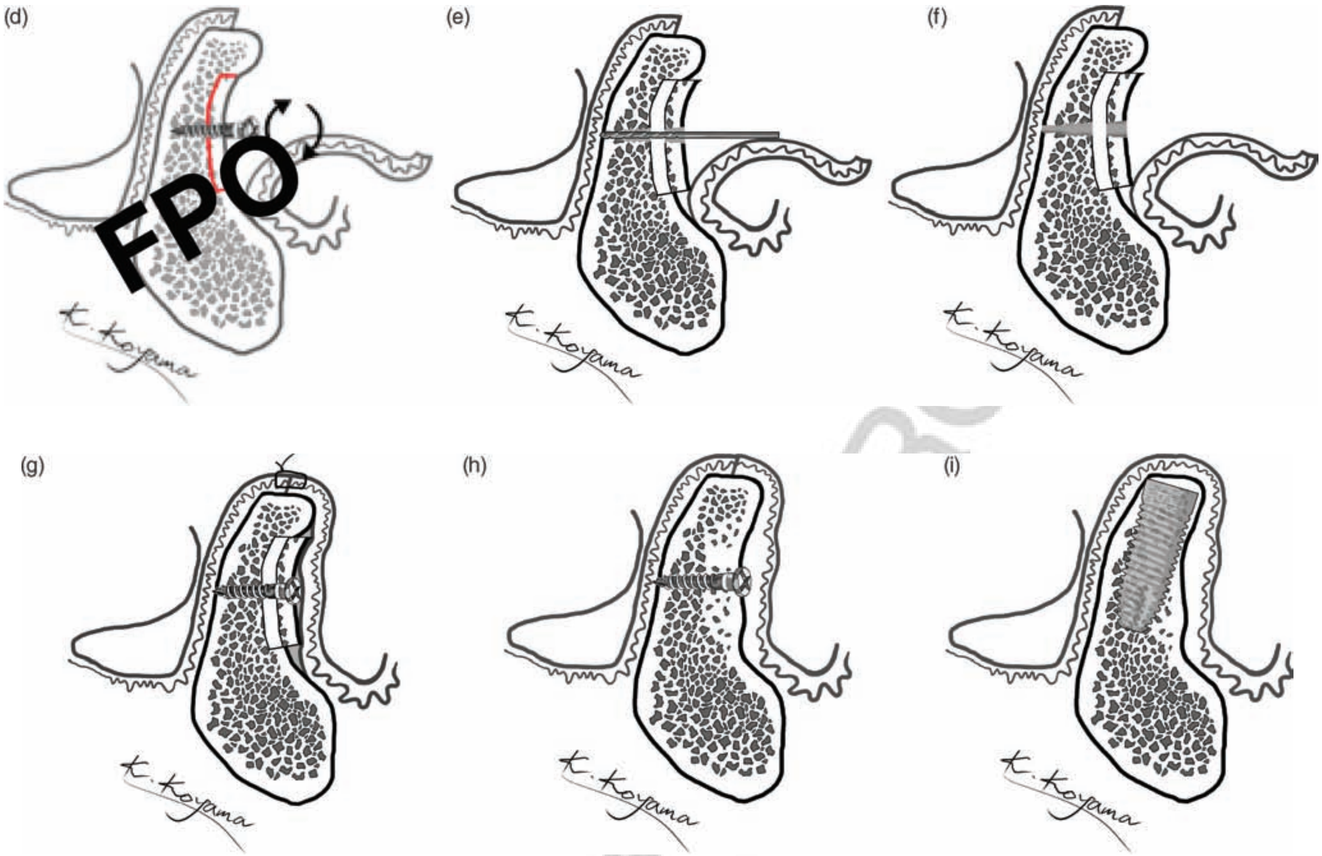

Figure 26.3 (*Continued*)

Case report 1 (Figure 26.4a to s)

A 52-year-old systemically healthy female was referred to the Dental Implant Center of Tohoku University Hospital for a fixed prosthetic rehabilitation from the first incisor to the canine of her left mandible. A pre-operative panoramic radiograph and a cone-beam computed tomography (CBCT) scan were performed to plan implant positioning and to evaluate alveolar residual bone anatomy. The horizontal defect of the middle portion was observed from CBCT images and has the risk for exposure of the implant surface using the standard procedure.

The pre-operative mean residual bone height of the canine region was 32 mm, the width of the crestal region was 5.7 mm and that of middle portion was 3.6 mm.

From these radiographic and dental cast evaluations, lateral a "cortical bone repositioning (CBR)" procedure was chosen to allow placement of two implants. The patient did not allow use of any biomaterial, especially made from an animal, so we planned to use only autogenous bone. The patient gave written informed consent to the treatment.

The CBR procedure was performed under local anaesthesia. A crestal incision was made, which extended vertically on the mesial and distal sides. The mucoperiosteum was reflected, exposing the labial surface of the bone. The block bone was designed at the atrophic area and then a monocortical osteotomy was performed using a 701 fissure bur and an ultrasonic bone-cutting device (Variosurg, NSK, Japan). The hole made in the center of the block allowed the screw to touch the lingual cortex. This was followed by insertion of a 1.7-mm-diameter self-tapping titanium screw (length 8 mm, Stryker) to the depth of the lingual cortex using a hand driver. Finally, the screwing procedure was continued to make the block bone pull out from the surrounding bone and the block was then displaced labially with the assistance of a thin-bladed osteotome. After confirming the lateral mobility of the block, the screw was removed and the drill was reinserted in the same hole of the lateral cortex to make a hole in the lingual cortex. The screw was inserted to fix the bone block at the lateral position as a positioning screw technique. Some bone taken by the bone scraper at the same surgical field was placed in the gap between the block and the original bone surface. Two implants (OsseoSpeed TX 4.0 S; length 11 mm, Dentsply Implant Company) were then inserted in a standard manner. Some bone chips taken from the surrounding area by the bone scraper were placed around the cortical bone block. After making periosteal releasing incisions to obtain a tension-free closure, the flap was closed by 5-0 Softretch (GC, Tokyo, Japan).

Antibiotics were given: 300 mg of Cefdinir (Astellas, Tokyo, Japan) orally for 4 days together with a non-steroidal anti-inflammatory medication Loxoprofen (Daiichi-Sankyo, Tokyo, Japan). The post-surgical instructions included a soft diet and 0.12% Chlorhexidine mouth rinses for oral hygiene. Panoramic radiograph were performed immediately after surgery. The patient was examined clinically 1 and 2 weeks and 1, 2, and 3 months after surgery. CBCT was taken 2 months after surgery and panoramic radiographs was taken 3 months after surgery. No complications were observed during the follow-up.

A secondary operation to set the healing caps was performed 6 months after the first surgery. The screw remained in the same position and most of the gap was filled with newly formed bone. The implants were stable without vertical bone resorption and movement. The final prosthesis was fixed 9 months after the first surgery.

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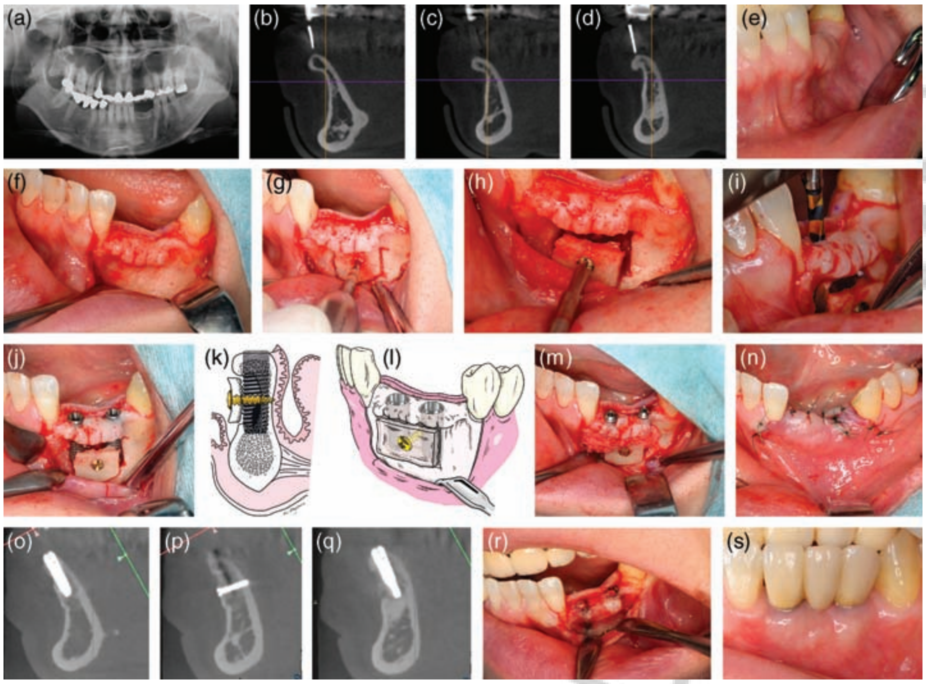

Figure 26.4 **(a)** Preoperative panoramic radiograph. **(b)** CBCT cross-sectional images. Two implants were planned at the medial and distal parts of the missing tooth area. The middle part of alveolar crest was dented, so the alveolar bone was observed as gourd-shaped in the sectional images: mesial section. **(c)** Middle section (center). **(d)** Distal section. **(e)** Preoperative clinical situation revealing a horizontal defect under the top of alveolar crest. **(f)** Crestal incision with additional buccal vertical incision of the adjacent tooth. **(g)** Making the bone block at the buccal cortex of the defect area; mono cortical drilling was performed to insert the titanium screw. **(h)** Self-tapping screw was inserted and touched to the lingual cortex and thescrewing procedure was continued until the block was fully mobilized to the buccal area. **(i)** The block was fixed with a screw by re-drilling and re-insertion to the lingual cortical bone; then a standard drilling procedure for a dental implant was performed as usual. **(j)** Implants were placed with secure initial stability. **(k)** Cross-sectional image of this technique. **(l)** Schematic image of simultaneous CBR and implant insertion. **(m)** Implants were placed at a planned location and the block was fixed with one screw with autogenous bone chips. **(n)** The wound was closed by soft nylon following periosteal releasing incisions. **(o)** Post-operative 2-month CBCT images. The width of the middle part of the alveolar crest was gained using the CBR procedure. The cortical bone width was not changed at the middle section; mesial section. **(p)** Middle section (center). **(q)** Distal section. **(r)** Clinical situation at the secondary operation revealing newly formed bone at the gap between the block and original bone and no bone resorption around the screw head. **(s)** Intraoral photograph after the set of final prosthesis.

Case report 2 (Figure 26.5a to k)

A 72-year-old healthy female was referred for a fixed prosthetic rehabilitation from the right central incisor to the left lateral incisor of the maxilla. A pre-operative panoramic radiograph and a CBCT scan were obtained to plan implant positioning and evaluate the residual alveolar bone anatomy. A horizontal defect was evident on the CBCT image and the implant surface was at risk of exposure if the standard procedure were to be employed. The pre-operative mean residual bone height of the canine region was 18 mm, the width of the crestal region 2.5 mm, and the width of the middle portion 3.6 mm. After radiographic and dental cast evaluation, the lateral CBR procedure was chosen to allow placement of two implants. The patient gave written informed consent to this treatment.

The CBR procedure was performed under local anesthesia. A crestal incision was initially made; this extended vertically on both the mesial and distal sides. The mucoperiosteum was reflected, exposing the labial surface of the bone. A bone block was designed to fit the atrophic area and monocortical osteotomy was performed using an ultrasonic bone-cutting device. A hole drilled in the center of the block allowed the screw to touch the lingual cortex. Next, a 1.7-mm-diameter self-tapping titanium screw (length 8 mm, Stryker) was inserted to the depth of the lingual cortex, using a hand driver. However, during screw insertion, the block fractured into several pieces, commencing at the hole. The two largest fragments were located laterally and superiorly and were fixed with titanium screws. The other fragments were returned to their original sites and Cerasorb (Curasan Inc., USA) was packed around the pieces, which were covered with a resorbable membrane (Koken Tissue Guide; Olympus Termo Biomaterials, Tokyo, Japan). After the creation of periosteal-releasing incisions to ensure tension-free closure, the flap was closed using 5-0 Softretch (GC, Tokyo, Japan).

During healing over 5 months, no complication such as bone dehiscence or infection was noted. A secondary operation was performed 6 months after the initial operation; the bone volume was adequate and no resorption around screws was evident upon raising of the mucoperiosteum flap. Two titanium screws were removed using a hand driver and two implants (OsseoSpeed TX 3.5 S; length 11 mm, Dentsply Implants) were inserted in the standard manner.

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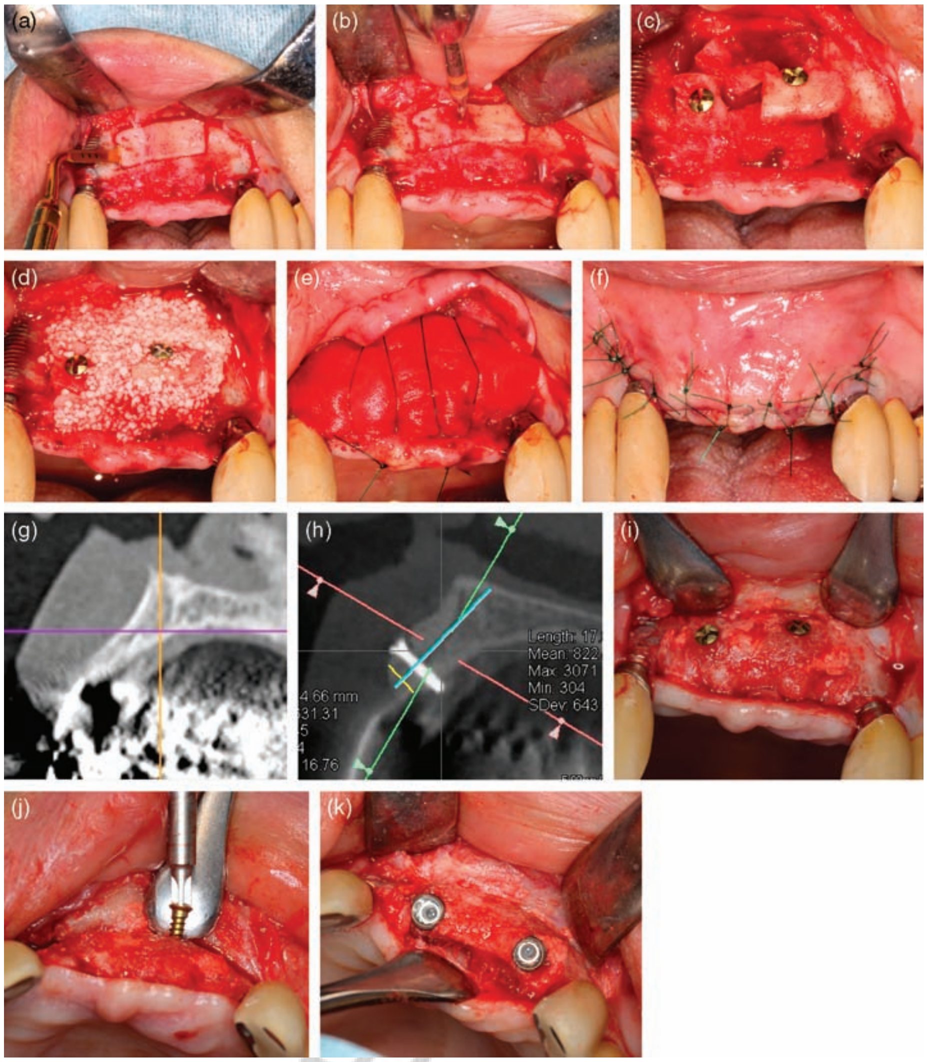

Figure 26.5 **(a)** Monocortical osteotomy was performed using an ultrasonic bone-cutting device. **(b)** Monocortical drilling was performed to insert the titanium screw. **(c)** Fracture happened to occur at mobilization of the mono cortical block. Two pieces of the fragments were fixed with the mini screws. **(d)** Bone chips and Cerasorb (Curasan Inc., USA) were placed around the pieces. **(e)** Augmented area was covered with a resorbable membrane (Koken Tissue Guide; Olympus Termo Biomaterials, Tokyo, Japan). **(f)** After creation of periosteal-releasing incisions to ensure tension-free closure, the flap was closed. **(g)** CT cross-sectional image before surgery. **(h)** CT cross-sectional image after a consolidation period for 3 months. **(i)** Second operation for the screw removal and implant insertion. Bone volume was adequate and no resorption around screws was seen. **(j)** Mini screws were removed using a hand driver. **(k)** Two implants (OsseoSpeed TX 3.5 S; length 11 mm, DENTSPLY Implants) were inserted in the standard manner.

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 [3]. Watzak et al. developed a horizontal DO technique using a micro bone screw [11]. This had all the advantages of DO and no volume limitation. However, disadvantages were also apparent, including the need for daily manual activation, a requirement for a secondary operation to remove the device, limitation of the distraction vector, and the risk of infection from the activation rod. Our previous experimental studies showed that bone regeneration might occur in secure regions under the periosteum. Lethaus et al. found no difference in bone formation after performance of dynamic and static procedures in which space was created under the titanium mesh [4]. CBR is a static procedure: a secure space is created under the periosteum via lateral replacement of the buccal cortical bone block. CBT is a one-stage procedure (post-operative activation is not required) and 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.

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 [12,13]. However, bone healing after DO occurs via callus formation, similar to the fracture-healing process, characterized by overlapping modeling exhibiting regional acceleration [14]. Regeneration after CBR is similar to bone healing after fracture; the osteotomized bone block is located laterally and does not overlap the cortical bone.

An extremely narrow alveolar bone with a small marrow space is at higher risk of cracking or fracturing of the cortical bone block at the point of separation from original bone. Thus, indications for CBR include cases with cancellous bony areas between the lateral and medial cortical bone. Furthermore, the initial stability of block bone 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.

CBR employs positioning screws used in osteosynthesis during oral and maxillofacial surgery. In our present case, we used a single self-tapping screw and drilling was performed prior to screw insertion. When a self-drilling screw is used, the tip of the screw must be narrow, compromising stability. Because the initial block stability is critical, we used a self-tapping screw. If stability remains inadequate, another screw can be placed or a screw of a wider diameter can be used.

Conventional grafting is associated with donor site morbidity; 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 are associated with infections, resorption after grafting, and additional costs. Titanium screws have long been used in maxillofacial surgery, such as ORIF, and orthognathic and reconstructive surgery. The screws are safe, afford good mechanical strength, and are of lower cost than biomaterials and devices.

Conclusion

The advantage of the CBR technique compared to autogenous grafts is the lack of donor side morbidity (co-morbidity). This technique has the possibility to induce the patient's regenerative ability for bone healing. Further clinical and experimental studies are needed to prove the stability and healing process for the treatment of horizontal defects in the alveolar region.

References

1 Takahashi T, Funaki K, Shintani H, Haruoka T: Use of horizontal alveolar distraction osteogenesis for implant placement in a narrow alveolar ridge: a case report. *The International Journal of Oral and Maxillofacial Implants* 2004 Mar–Apr;**19**(2):291–294.

2 Yamauchi K, Takahashi T, Funaki K, Yamashita Y: Periosteal expansion osteogenesis using highly purified beta-tricalcium phosphate blocks: a pilot study in dogs. *Journal of Periodontology* 2008;**79**:999–1005.

3 Yamauchi K, Takahashi T, Nogami S, Kataoka Y, Miyamoto I, Funaki K: Horizontal alveolar distraction osteogenesis for dental implant: long-term results. *Clinical Oral Implants Research* 2013;**24**:563–568.

4 Lethaus B, Tudor C, Bumiller L, Birkholz T, Wiltfang J, Kessler P: Guided bone regeneration: dynamic procedures versus static shielding in an animal model. *Journal of Biomedical Materials Research. Part B, Applied Biomaterials* 2010;**95**: 126–130.

5 Blus C, Szmukler-Moncler S. Split-crest and immediate implant placement with ultra-sonic bone surgery: a 3-year life-table analysis with 230 treated sites. *Clinical Oral Implants Research* 2006;**17**:700–707.

6 Garcez-Filho J, Tolentino L, Sukekava F, Seabra M, Cesar-Neto JB, Araújo MG: Long-term outcomes from implants installed by using split-crest technique in posterior maxillae: 10 years of follow-up. *Clinical Oral Implants Research* 2015;**26**:326–331.

7 Iglhaut G, Schwarz F, Gründel M, Mihatovic I, Becker J, Schliephake H: Shell technique using a rigid resorbable barrier system for localized alveolar ridge augmentation. *Clinical Oral Implants Research* 2014;**25**:e149–154.

8 Stimmelmayr M, Güth J-F, Schlee M, Beuer F: Vertical ridge augmentation using the modified shell technique – a case report. *Journal of Oral and Maxillofacial Surgery: Official Journal of the American Association of Oral and Maxillofacial Surgeons* 2014;**72**:286–291.

9 Becktor JP, Rebellato J, Sollenius O, Vedtofte P, Isaksson S: Transverse displacement of the proximal segment after bilateral sagittal osteotomy: a comparison of lag screw fixation versus miniplates with monocortical screw technique. *Journal of Oral and Maxillofacial Surgery: Official Journal of the American Association of Oral and Maxillofacial Surgeons* 2008;**66**:104–111.

10 Ellis E: Is lag screw fixation superior to plate fixation to treat fractures of the mandibular symphysis? *Journal of Oral and Maxillofacial Surgery: Official Journal of the American Association of Oral and Maxillofacial Surgeons* 2012;**70**:875–882.

11 Watzak G, Zechner W, Tepper G, Vasak C, Busenlechner D, Bernhart T: Clinical study of horizontal alveolar distraction with modified micro bone screws and subsequent implant placement. *Clinical Oral Implants Research* 2006;**17**:723–729.

12 Hallman M, Cederlund A, Lindskog S, Lundgren S, Sennerby L. A clinical histologic study of bovine hydroxyapatite in combination with autogenous bone and fibrin glue for maxillary sinus floor augmentation. Results after 6 to 8 months of healing. *Clinical Oral Implants Research* 2001;**12**:135–143.

13 Petrungaro PS, Amar S: Localized ridge augmentation with allogenic block grafts prior to implant placement: case reports and histologic evaluations. *Implant Dentistry* 2005;**14**:139–148.

14 Frost HM: The biology of fracture healing. An overview for clinicians. Part I. *Clinical Orthopaedics and Related Research* 1989Nov;**248**:283–293.

15 Buser D, Brägger U, Lang NP, Nyman S. Regeneration and enlargement of jaw bone using guided tissue regeneration. *Clinical Oral Implants Research* 1990;**1**:22–32.

16 Chiapasco M, Zaniboni M: Clinical outcomes of GBR procedures to correct peri-implant dehiscences and fenestrations: a systematic review. *Clinical Oral Implants Research* 2009;**20**Suppl4:113–123.