Vertical ridge augmentation using the split bone block technique

Chang IC Teoh describes the case management of an atrophic anterior mandible employing an alternative approach to autogenous tissue grafting

This is the third article in a series on different techniques for vertical ridge augmentation (VRA).

The last article described a case of VRA that used an autogenous bone block graft to reconstruct an atrophic posterior mandible before implant placement. Autogenous bone grafts are regarded as the gold standard material for bone reconstruction (Miron and Zhang 2019). However, autogenous block grafts may undergo resorption.

Cordaro et al (2002) showed a 23.5% reduction in horizontal ridge augmentation and 42% reduction in vertical augmentation using autogenous bone blocks harvested from the mandible (retromolar or symphysis region).

The use of barrier membrane and xenograft seems to reduce the tendency of graft resorption Maiorana et al 2005). However, their use may cause complications such as soft tissue dehiscence, slow down the revascularisation of the graft (Jensen and Terheyden 2009) and increase the cost of the treatment.

The importance of blood supply to bone healing in orthopaedics has been well established. Blood supplies oxygen, nutrients and regulatory factors to tissues, as well as removing metabolic waste products such as carbon dioxide and acid.

The general pattern of bone cell activity following fracture or osteotomy is broadly consistent with the known responses of osteoblasts and osteoclasts to changes in pO2. Inadequate or slow revascularisation of the osteotomy site may lead to a hypoxic phase that favours osteoclast recruitment, while at the same time, inhibiting osteoblast activity (Marenzana and Arnett 2013).

Schmid et al (1997) clearly demonstrated that the formation of blood capillaries precedes bone formation in the bone regeneration process. Rapid

FIGURE 1: Patient at presentation

FIGURE 2: Narrow mandibular ridge with combination defect

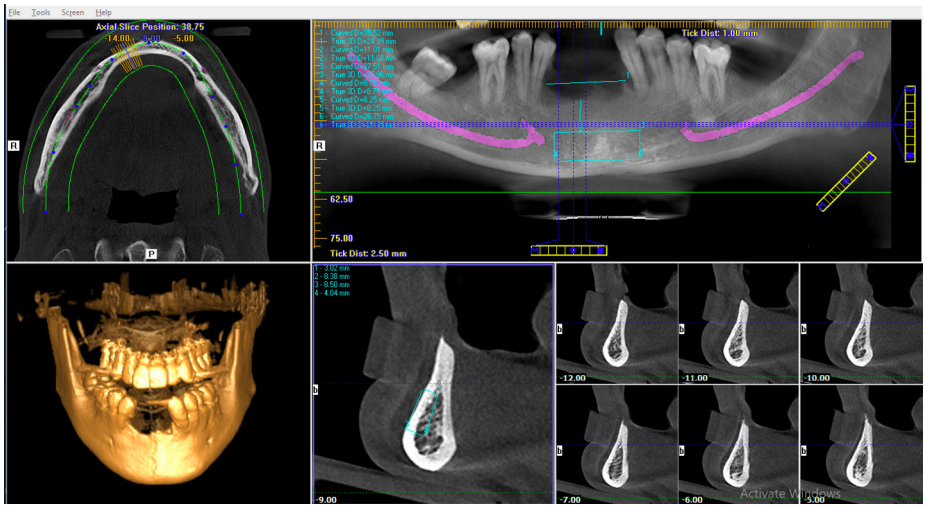

FIGURE 3: Preoperative CBCT assessment of bone defect

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revascularisation is thus a key factor of graft survival and this can be facilitated by creating holes in the recipient bed (Khoury et al 2007).

Autogenous grafting

Autogenous bone grafts are rich in cells, bone matrix and bioactive molecules such as bone morphogenic proteins (BMPs).

However, without rapid revascularisation, the osteocytes inside their lacunae will not survive. Without the essential cellular element within the bone graft, it may become non-vital and may not respond to the loading stimulus when implants are inserted.

Cortical bone block is mostly composed of compact bone and that will make it difficult to revascularise rapidly.

Zerbro et al (2003) demonstrated that majority of osteocytes within the bone blocks do not survive grafting. Acocella et al (2010) reported that after histologic evaluation of healed mandibular ramus bone block grafts, these grafts contained significant amounts of nonvital bone.

Conversely, trabecular bone will revascularise rapidly because of its architecture.

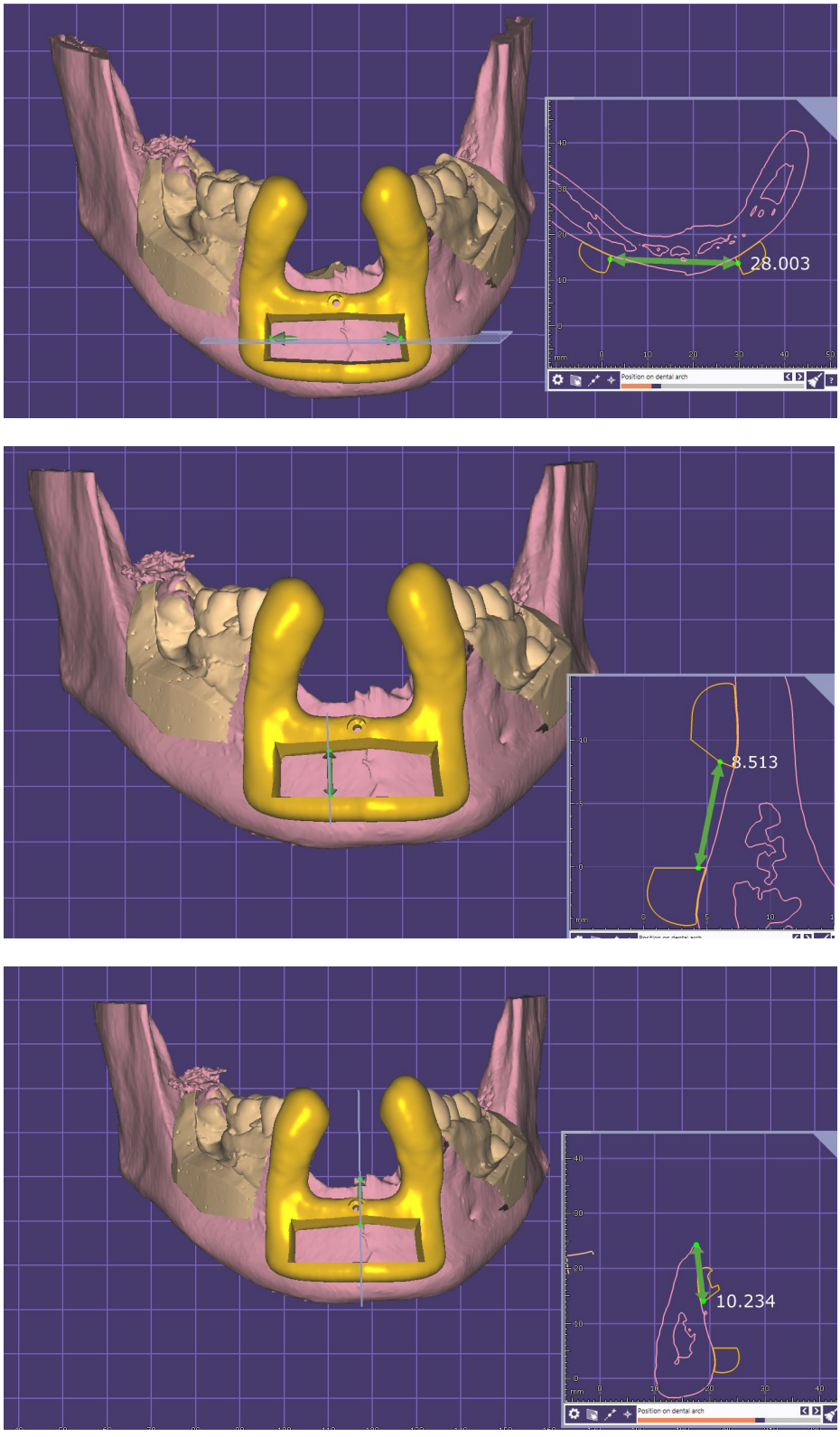
It has been shown that vascularisation in cancellous bone is almost 10 times faster (0.5mm per day) than in cortical compact bone (0.05mm per day) (Schenk and Willenegger 1967; Rhinelander 1974).

Burchardt (1983) described the distinctive difference in repair of cancellous and cortical bone grafts. Cancellous grafts are revascularised more rapidly and completely than cortical grafts and cancellous grafts tend to repair completely with time, whereas cortical grafts remain as admixtures of necrotic and viable bone.

Split bone technique

Khoury (Khoury et al 2007; Khoury and Hanser 2015) first described an ingenious split bone block (SBB) technique of dividing an autogenous bone block into two smaller blocks.

The cortical compact bone volume of the blocks is further reduced into thin plates of roughly 1mm thick using a bone scraper. The bone scraper transforms the compact architecture of cortical bone into loosely arranged cancellous bone, covered with patient's blood, thereby increasing the overall surface area and volume of the autogenous block graft significantly.



FIGURES 4-6: Fabrication of the bone block harvesting guide

Kalchthaler et al (2020) conducted animal studies by comparing the amount of bone gain using two different techniques – autogenous bone block against split bone block of the same volume.

They found that the SBB technique can double the volume of bone gain (mean gain of 0.78cm^3) compared with a conventional bone block technique (mean gain of 0.36cm^3). The reported resorption rate of SBB after 10 years is 8.3% in posterior maxilla vertical ridge augmentation (Khoury and Hanser 2015).

Another feature of the SBB technique is

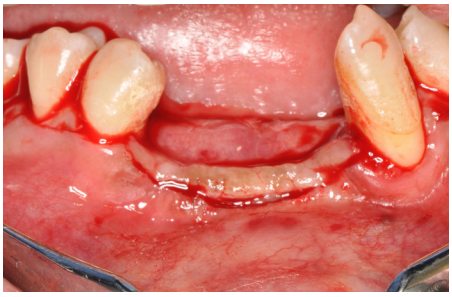
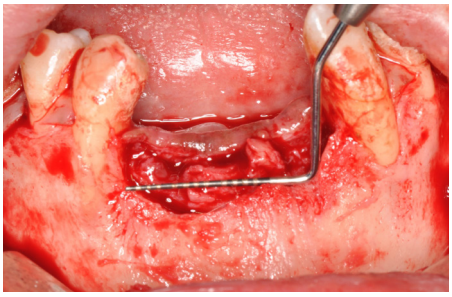


FIGURE 7: Initial incision made at the buccal aspect



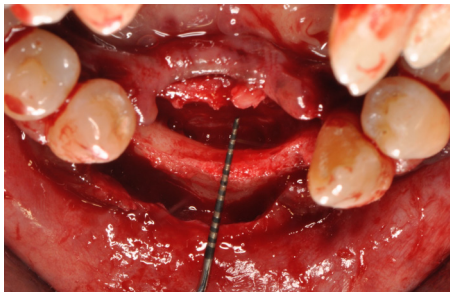


FIGURE 8 & 9: The incision fully exposed the anterior part of the mandible

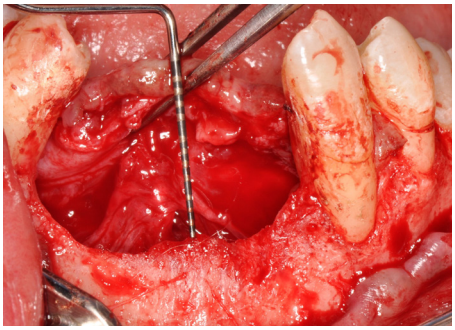


FIGURE 10: Mobilisation of the lingual flap

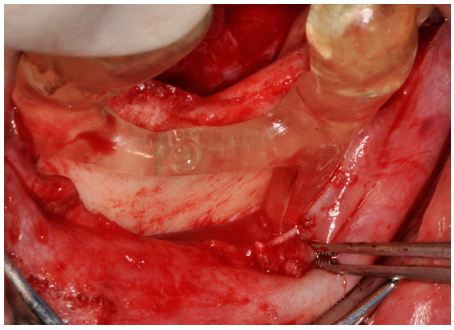


FIGURE 11 & 12: The CAD/CAM bone harvesting guide was fitted and stabilised with screws

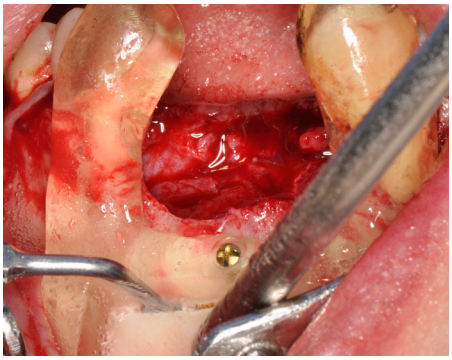


FIGURE 13: Piezosurgery was used for the osteotomy

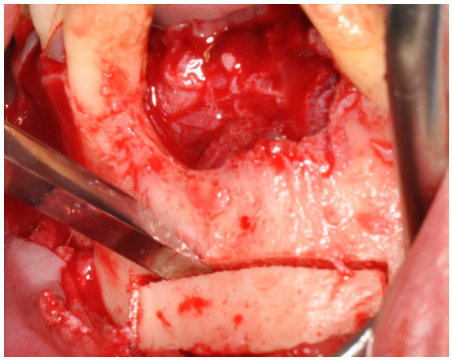


FIGURE 14: Careful luxation of the bone block

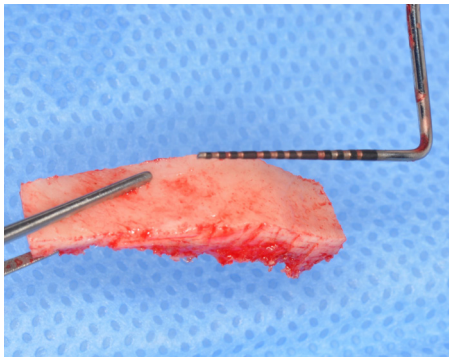


FIGURE 15: An autogenous corticocancellous bone block was obtained

FIGURE 16: A Microsaw was used to split the block

the intentional placement of cortical plates at a distance from the recipient bed to reconstitute the original contour or outline of the alveolar ridge.

The cortical plates, which are stabilised with micro-screws, provide mechanical stability and resistance to the overlying muscle and soft tissue movement; hence graft immobility is ensured. They create an enclosed space to be filled with cancellous autogenous bone chips in direct contact with the recipient bed.

The cancellous bone allows rapid revascularisation of the entire graft and hence, its survival and regeneration and three-dimensional volume stability.

Case presentation

A healthy 39-year-old gentleman presented with an atrophic anterior mandible for implant rehabilitation.

He lost his anterior lower incisors due to advanced periodontal disease. His dentist provided him a temporary denture and he could not tolerate it. The patient was asking for fixed implant restorations.

The anterior mandibular ridge was thin and narrow with a combination vertical and horizontal defect (Figures 1 & 2). The ridge defect was classified as C.2.e according to the Cologne classification of alveolar ridge defects (CCARD). A preoperative diagnostic wax up was carried out and the anterior defect would be restored with a three-unit fixed bridge supported by two implants after bone augmentation.

After a careful discussion with the patient, a treatment

The split bone block technique can double the volume of bone gain compared with a conventional bone block technique

plan of rebuilding the alveolar ridge using autogenous bone and subsequent implant placement and restoration was proposed.

The patient gave his consent for the proposed treatment by signing the consent documents.

Treatment planning

The ridge would be rebuilt with the SBB technique using autogenous bone harvested from the symphyseal region. The symphyseal region was selected instead of the retromolar region due to the close proximity of the defect and donor site and the natural curvature contour.

A preoperative analysis with CBCT scan gave an accurate assessment of the dimension of the bone defect (Figure 3). The defect was 26mm in mesio-distal linear dimension and 6mm in height. The plan was to obtain an autogenous block graft of a dimension of 28mm x 8mm and 3mm, at least 8mm from the apex of the anterior teeth (LL3) and from the mental foramen. A computer-guided bone block harvesting guide (Stavola and Tunkel 2014) was fabricated (Figures 4-6).

Bone augmentation

The patient was carried out under LA with no sedation. Premedication was prescribed one hour before the operation.

An initial incision was made on the buccal aspect instead of in the crestal region (Figure 7) and was carried posteriorly beyond the mental foramen on both sides to fully expose the anterior part of the mandible (Figures 8 & 9).

The next step was to mobilise the lingual flap (Figure 10), an important part of flap management for vertical augmentation in anterior mandible. The periosteum of the lingual flap was gently separated with sweeping motion of a PP Buser elevator. The flap was further stretched using a brushing motion, taking great care not to cause any perforation of the soft tissue.

The CAD/CAM bone harvesting guide was fitted onto the LR4 and LR3 and further stabilised with an osteosynthesis screw of 1.25mm diameter (Straumann) through an access hole in the middle of the guide (Figures 11 & 12). The guide served to lineate the dimension of autogenous bone to be harvested. Piezosurgery (Piezotome Cube, Acteon) was used to carry out the osteotomy.

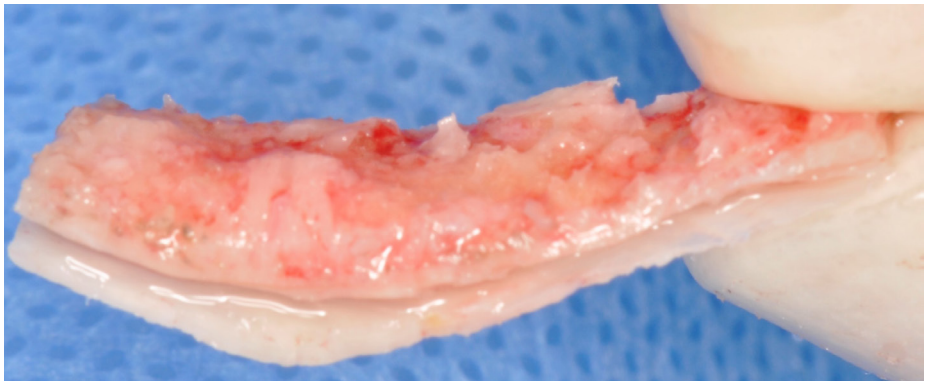


FIGURE 17: The bone block was divided into two thin plates

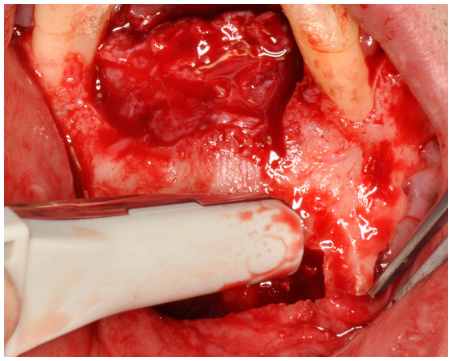
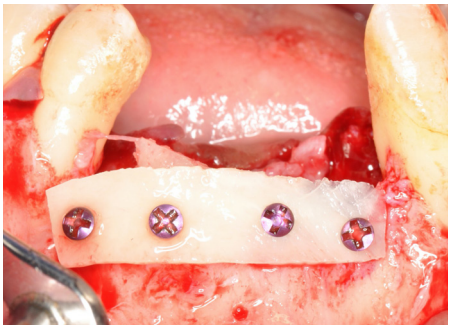
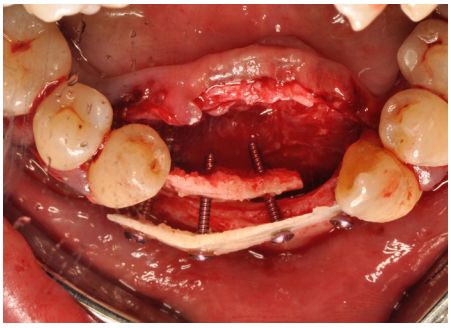


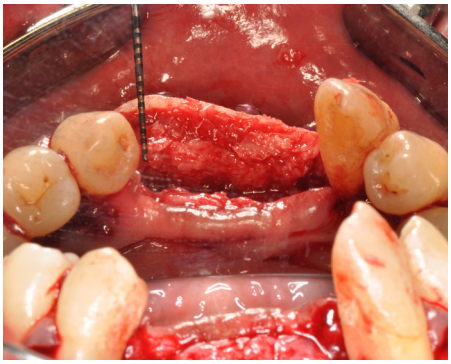
FIGURE 18: Harvesting of autogenous bone chips

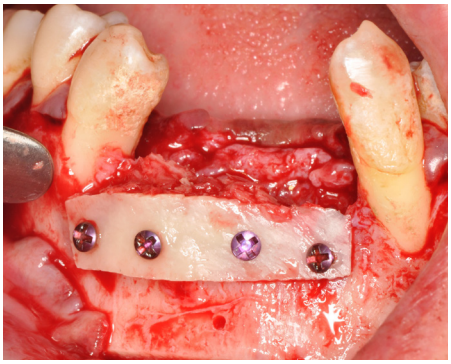
FIGURE 19: Preparation of the bone graft





FIGURES 20 & 21: Placement of bony plates, secured by osteosynthesis screws





FIGURES 22 & 23: The space between the split plates was filled with autogenous bone chips

The osteotomy cuts were made with the Acteon saw like BS1 piezosurgical tip (Figure 13). It went through the outer cortex of the anterior mandible to a depth of 3mm, following the parameter prescribed by the guide.

The CAD/CAM guide was then removed once the osteotomy was completed and the autogenous bone block was carefully luxated out of its housing with gentle tapping of a mallet and a chisel (Figure 14). An autogenous corticocancellous bone block

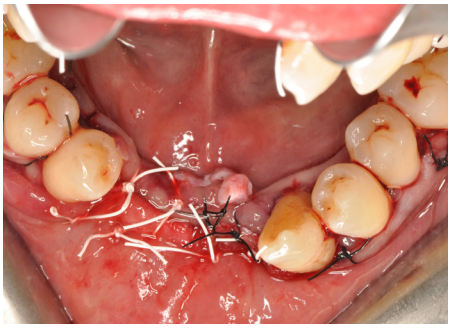
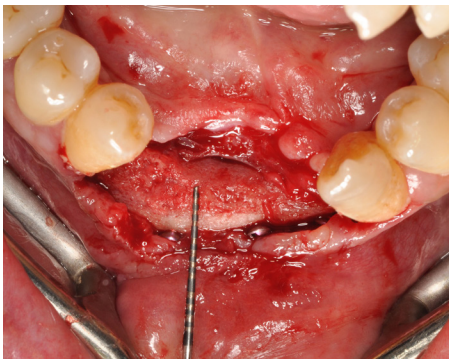
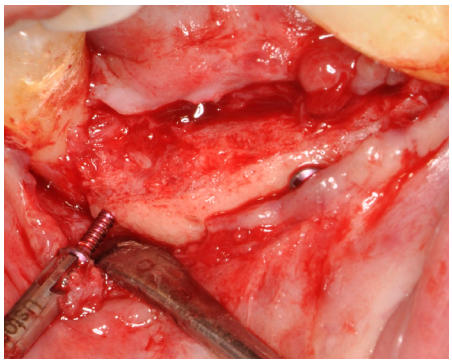


FIGURE 24: Wound closure with multiple sutures

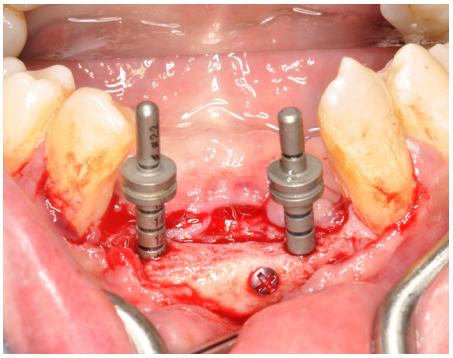
FIGURE 25: Healing after four months

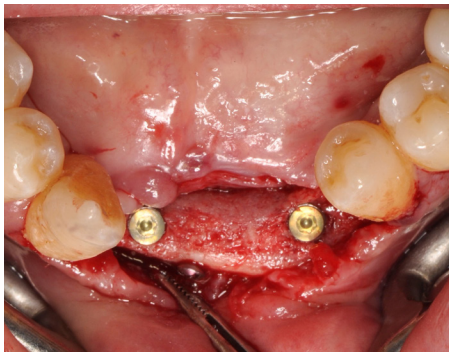


FIGURES 26: The regenerating bone was sufficient in volume and striking in quality



FIGURES 27: All screws bar one were removed





FIGURES 28 & 29: Placement of Straumann implants in optimal restorative positions

of the prescribed dimension was obtained (Figure 15). The donor site was filled with collagen sponge.

The bone block was split with a Friadent Microsaw (Dentsply Sirona), which has a thickness of 0.25mm and a diameter of 3.2mm (Figure 16). The separation was kept within the cortical part of the bone block: a piezosurgical tip was used to cut the cortical bone deeper within the block beyond the reach of the Microsaw.

The bone block was divided with ease into two thin plates of approximately 1mm in diameter (Figure 17).

Autogenous bone chips were harvested with Bonescraper (Meta) along the edges of the osteotomy site (Figure 18). Bone chips harvested with bone scraper were found to have higher osteogenic potential compared with other harvesting techniques (Miron and Zhang 2019).

An autogenous bone graft of two distinctively different microarchitectures was prepared (Figure 19). The buccal bone plate was secured with two osteosynthesis screws of 1.2mm diameter (Ustomed) to the alveolar ridge. Two more osteosynthesis screws provided anchorage of the lingual plate.

All four osteosynthesis screws were placed from the buccal aspect and the bony plates were placed at a distance from the recipient bony bed (Figures 20 & 21). No preparation of the recipient bed was carried out.

An area of 6mm in width was created, between the plates. It was then filled with autogenous bone chips (Figures 22 & 23).

A buccal flap was then mobilised and tension free flap closure achieved with internal and external sutures as described by Stavola and Tunkel (2014). Care was taken not to damage the mental nerve emerging from the foramen on both sides.

A completely tension-free flap closure was achieved by approximating the lingual and buccal flap together and the wound was closed with multiple sutures (Figure 24). Healing was mostly uneventful, although the patient reported a transient paraesthesia of the lower right lip. The sensation returned to normal three weeks after the operation.

Implant placement

Four months after the VRA procedure, a CBCT scan showed that new bone was regenerated, and it was ready for implant placement. There was loss of vestibule depth and lack of keratinised mucosa in the augmented site (Figure 25).

LA infiltration was administrated, and a full thickness flap was raised. Sufficient bone volume was regenerated, and the quality of regenerated bone was strikingly impressive (Figure 26).

All except one osteosynthesis screws were removed (Figure 27) and two Straumann BLT NC Roxolid SLA implants were placed in accordance with protocol in the optimal restorative positions (Figures 28 & 29). Both implants exhibited high insertion torque values (> 35Ncm).

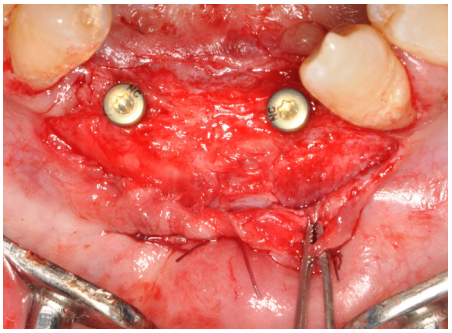
Flap closure was made with simple interrupted sutures and healing was uneventful.

Implant exposure and restoration

Two months after implant insertion, the implants were exposed.

Soft tissue surgery including partial thickness apical repositioned flap and free gingival graft were carried out to improve the soft tissue condition around the implants (Figures 30 & 31).

The implants were well integrated and healing abutments were connected to implants. The remaining osteosynthesis screw was removed.



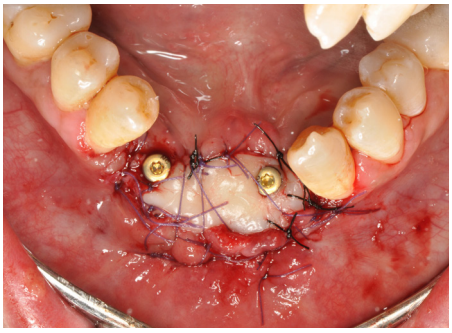


FIGURE 30 & 31: Exposure of implants after two months and soft tissue surgery carried out

FIGURE 32: After soft tissue healing the patient was sent back to the referring dentist for final restoration

Once the soft tissue healing had completed, the patient was then sent back to the referring dentist to complete the fixed implant restoration (Figure 32).

Conclusion

This article presents a case of vertical and horizontal augmentation with the split bone block (SBB) technique first described by Khoury.

The principle of SBB technique is to reduce the amount of dense cortical bone within the autogenous bone block and transform it to a more porous cancellous bone.

This will increase the overall surface area of the grafting material significantly and, at the same time, allow rapid vascularisation and release the bone morphogenic proteins inside cortical bone to kickstart the bone repair process, hence graft survival rate is enhanced.

Bone regeneration will take only three to four months – a much shorter time than GBR. The thin cortical plates restore the outline contour of the defect and provide the mechanical stability to the cancellous bone graft within.

Unlike with GBR techniques using biomaterials, there is no need to overbuild the contour of the ridge defect and no barrier membrane is needed, which would reduce the incidence of wound dehiscence.

The regenerated bone is composed of 100% autogenous bone of optimal architecture with outer cortical bone and inner cancellous bone filled with vital cellular activities. **IDT**

It has been shown that vascularisation in cancellous bone is almost 10 times faster than in cortical compact bone

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