The bone core technique:

Reconstructing peri-implant bone defects using minimally invasive autologous bone augmentation

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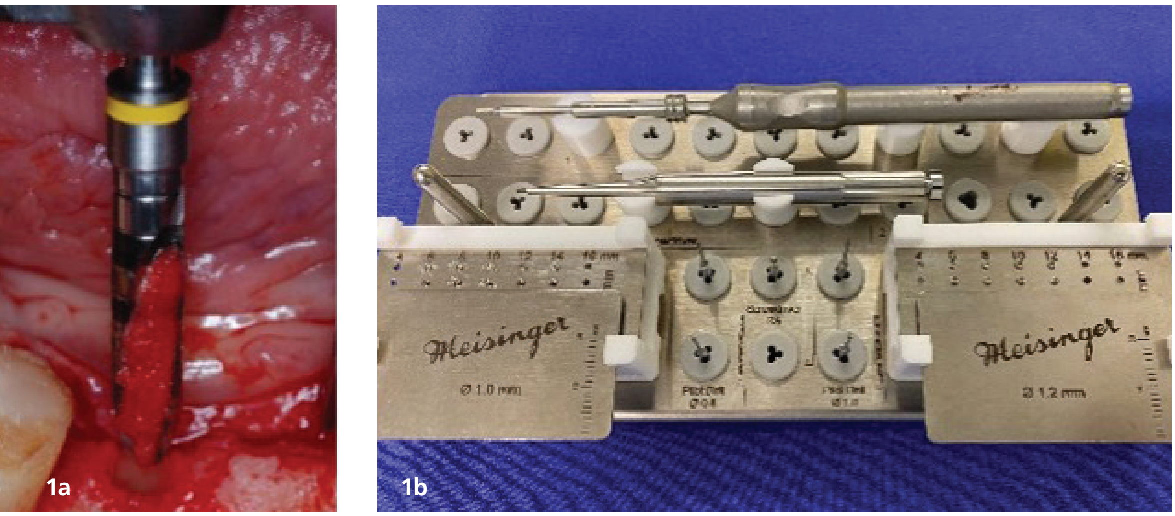
Gentle preparation of the implant site and the harvesting of bone from the site using minimally invasive trephine burs are basic prerequisites for the predictable augmentation of alveolar ridge defects using the autologous bone core technique. Pilot drilling is performed with a two-piece trephine bur to harvest the maximum amount of bone for augmentation. Advantages include reduced morbidity due to the elimination of an additional donor site, reduced treatment time, and no need for membranes or foreign-material substitutes. As an autologous augmentation technique, the bone core technique is (as known as carot technique) characterised by a high osteoconductive, osteoinductive and osteogenic potential. Autologous bone grafts remain the gold standard in dental implantology due to their biological advantages.

Removal of non-salvageable implants or teeth initiates resorption processes that can significantly compromise the osseous implant site. For aesthetic and prosthetic-functional reasons, augmentation is often required to reconstruct lost hard and soft tissue. The complex rehabilitation of these defects by hard- and soft-tissue augmentation has become an established procedure.[1]

There are several surgical techniques to replace lost hard tissue. Techniques, potential bone-harvesting sites and available substitute materials have been evaluated in a number of studies.[1–3] A number of factors need to be considered to ensure the success of these, sometimes extensive, surgical procedures. Prominent among them is a biological understanding of the regeneration processes in the bacterially colonised oral cavity. Predictable augmentation is a prerequisite for subsequent implant placement in a prosthetically tenable position.[1,4]

To date, autologous bone is still considered the gold standard in oral implantology, especially for lateral and vertical augmentation sites.[5–8] Autologous bone is characterised by excellent osteoconductive, osteoinductive and osteogenic



1a 1b

Fig. 1a: Harvesting bone chips during implant bed preparation at low drill speed and without irrigation. **Fig. 1b:** The microscrew kit.

properties.[3] Graft materials of different origins have only osteoconductive properties. Bone block grafts can be obtained in various shapes and sizes, both extra- and intraorally.[9] Although autologous bone chips can be harvested from various intra-oral sites, they are not dimensionally stable and are therefore usually mixed with bone substitute materials and covered with resorbable or non-resorbable membranes for crestal bone augmentation.[10–12] In addition to the risk of early membrane exposure and associated infection, which can lead to the loss of the augmentation material, this treatment modality is associated with long healing times of up to nine months and expensive materials.[12–14]

Bone block grafts used for the shell technique are most commonly harvested from the external oblique line of the mandibular ramus and can usually be used successfully for all forms of bone augmentation.[1,9,15] These bone block grafts can be harvested reliably and reproducibly, but the procedure imposes a certain burden on the patient due to the need for a second surgical site.

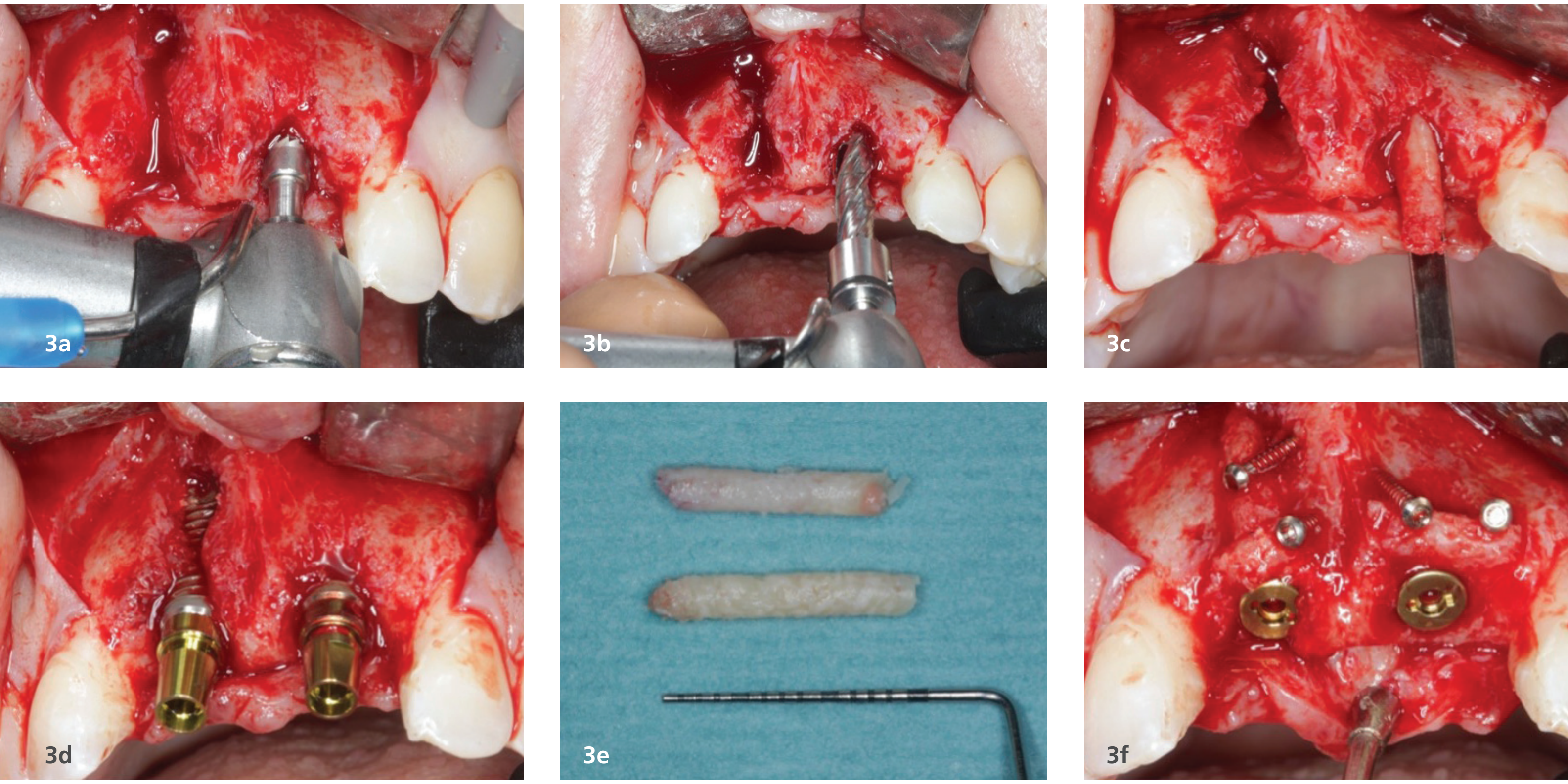
The bone core technique is based on the use of bone harvested locally at the implant site and has been used successfully in many indications.[2] This article describes and discusses this minimally invasive method of bone augmentation based on a case series covering various indications.

Materials and methods

The bone core technique is based on removing a stable core of bone from the future implant site using a trephine bur. Additional bone chips are harvested during the various drilling steps until the final diameter of the implant bed is reached. Implant drilling is performed at low speed (approximately 80–120 rpm) in well-moistened alveolar bone and without cooling (Fig. 1a). If the implant site is poorly perfused due to the vasoconstrictive effect of the local anaesthetic, the socket is irrigated with saline to prevent bone damage due to overheating. The range of indications for the bone core technique is limited to defect situations where the residual width of the alveolar ridge allows simultaneous implant placement within its contours accompanied by a bone deficit in the buccal or palatal/lingual bone wall. After implant placement, the bone core in the crestal region of the bone defect is compressed and stabilised against the implant surface with microscrews (Fig. 1b). The remaining free implant threads are covered with bone chips, and the voids are filled.[9]

It is not uncommon for the bone core to break out of the implant bed during drilling and remain in the trephine. Drilling and subsequent removal from a one-piece system can be complicated, especially if the cutting performance of the trephine is inadequate due to prolonged use. This can cause the trephine to derail due to lack of guidance, particularly in cortical bone. To simplify this technique, a two-part trephine kit (Meisinger) has been developed with four different trephine diameters and corresponding pre-trephines (Figs. 2a–e). The pre-trephines mark the harvesting area and guide the trephine for safe and precise drilling (Figs. 3a & b). The trephine burs are externally and internally cooled to prevent overheating of the bone core and future

Fig. 2a: The trephine kit. **Fig. 2b:** Four pre-trephines with different diameters. **Fig. 2c:** Four different diameter trephines. **Fig. 2d:** Two-piece trephine bur. **Fig. 2e:** The bone core can be easily retrieved after removal of the coronal part of the trephine.



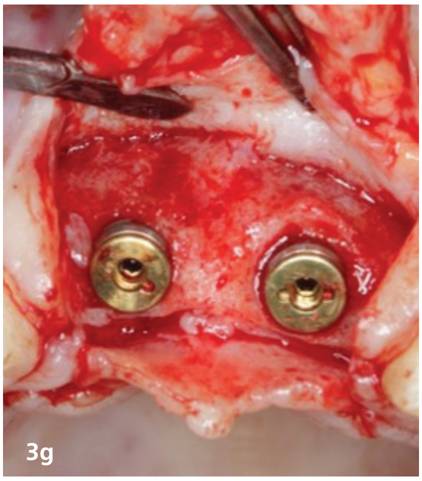
implant bed by a constant supply of coolant.[9,16] Intermittent operation is also recommended to allow better irrigation. The two-piece trephine bur allows easy removal of the bone core from the cylinder of the trephine bur. If the bone core remains in the area of the bone harvesting site, it is removed using a special bone core elevator (Meisinger; Fig. 3c).

Surgical procedure

Perioperative antibiotic therapy with penicillin 1,000,000 IU is administered, either intravenously immediately before the local anaesthesia or orally one hour before surgery, to be continued postoperatively for one week at a maintenance dose of 3 × 1,000,000 IU/day, depending on the extent of the augmentation site. In patients with a confirmed allergy to penicillin, clindamycin is given at a daily dose of 1.2 g. Following lingual/palatal and buccal infiltration with the local anaesthetic (4% articaine, 1:100,000 epinephrine), the bone surface including the defect is exposed by raising a full-thickness mucoperiosteal flap.

The morphology of the defect is then analysed. Implant placement with simultaneous bone grafting is only indicated if all implant threads can be placed within the bone envelope. The bone contour is determined by the bone height and the positions of the adjacent teeth and the placement of the implant site. All implant threads should be positioned at least 1 mm inside the bony envelope[9]—this is important for vascularisation of the bone graft and osseointegration of the implant. Therefore reason, wide sockets (Fig. 3a) are a good indication for the bone core technique, regardless of the extent of the bone defect.

After selecting the appropriate trephine bur for the selected implant diameter, the centre of the bone at the selected implant position is punch-marked with an appropriate pre-trephine. In the molar region, this mark should be placed in the septum area; in the anterior or premolar region, it should be slightly offset palatally to obtain a maximum of bone material. The trephine is then inserted over the punch mark to the desired depth to harvest the bone core (Fig. 3b).



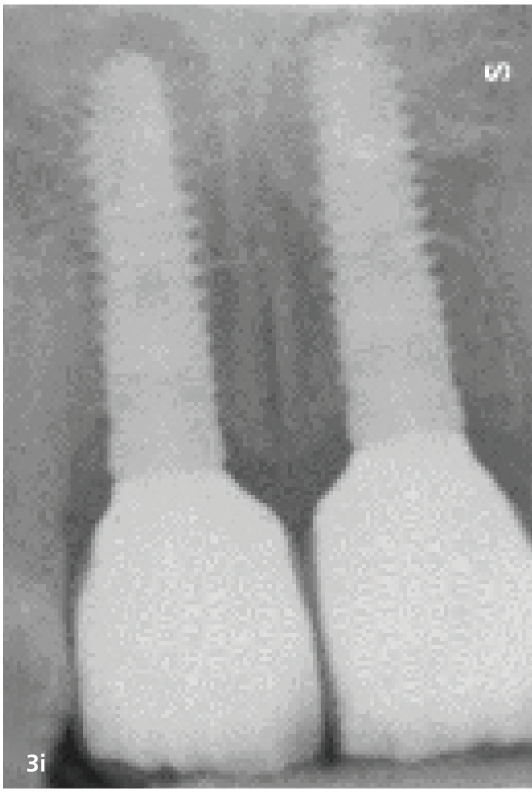


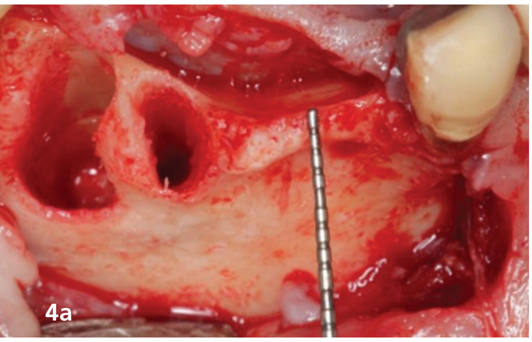
Fig. 3a: Absence of the vestibular bone wall at site 11 with a small bone defect at site 21. A pre-trephine is used to punch-mark site 21. **Fig. 3b:** The trephine bur with stable guidance thanks to the central punch mark. **Fig. 3c:** If the bone core is still attached to the bone, it can be easily removed using the bone core elevator. **Fig. 3d:** Defect situation after placement of implants 21 and 11 with exposed implant threads within the alveolar ridge envelope. **Fig. 3e:** The bone cores. **Fig. 3f:** The harvested bone cores were compressed against the implant surface with two microosteosynthesis screws each to restore the vestibular bone walls. The remaining defects were filled with the autologous bone chips. **Fig. 3g:** Clinical situation at three months. The bone defects have completely regenerated. **Fig. 3h:** Clinical situation at one year after definitive restoration. **Fig. 3i:** Control radiograph at one year.

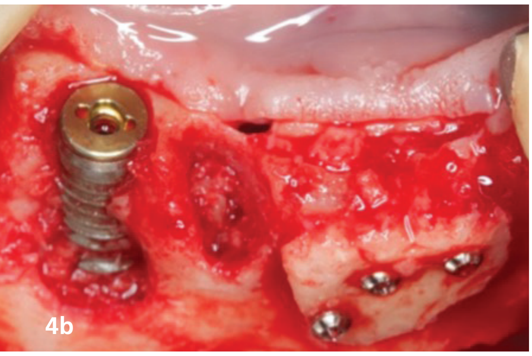
Once the bone has been removed, the implant bed is carefully expanded to the desired depth and diameter. The implants are then placed within the bone envelope (Fig. 3d). As the diameter of the initial trephine should be smaller than the implant diameter, additional autologous bone chips can be harvested at low speed without irrigation. The bone core is usually compressed and stabilised against the implant using two microscrews (1.0 or 1.2 mm diameter; Meisinger; Fig. 3e). The screws must apply compression only through the screw head to secure the bone core in place without penetrating it. In some cases, multiple bone cores from different prepared implant beds may be used to augment a larger defect (Fig. 3f).

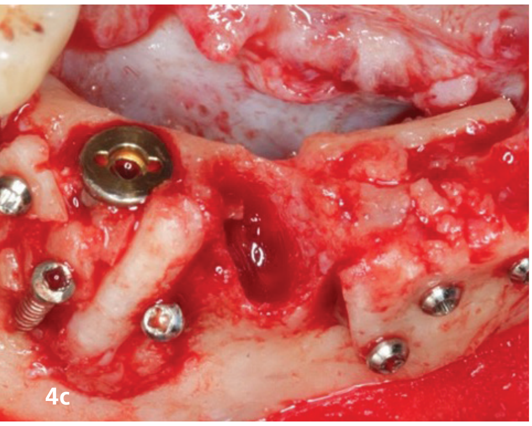
If sufficient bone chips cannot be obtained for augmentation during implant bed preparation, it is recommended to obtain additional local bone chips using a bone scraper. After tension-free wound closure, the site is re-entered after only three months. A full-thickness flap is elevated is used to clinically visualize the completely regenerated bone (Fig. 3g). The prosthetic restoration can be initiated simultaneously (Figs.3h & i).

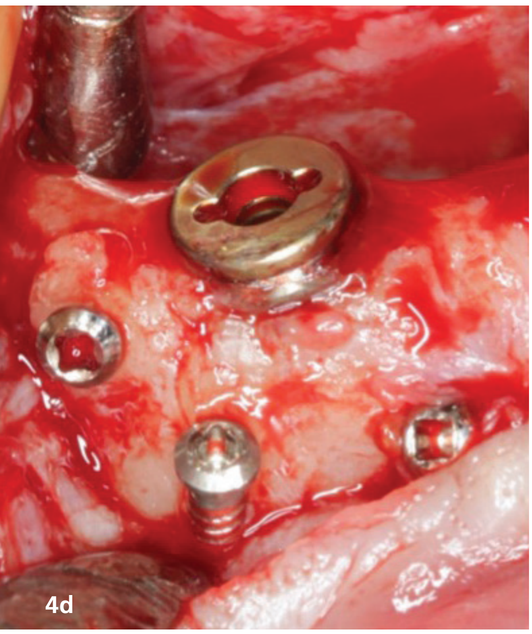
Guided by the morphology of the defect and the remaining bone walls, bone is harvested with the trephine close to the still intact bone wall, but taking into account the prosthetic plan, occlusion, and any pronounced undercut areas. In the maxilla, a bone core removal is usually harvested palatally because, on the one hand, the bone defects are usually located in the area of the vestibular bone wall and, on the other hand, this allows the implant threads to remain within the jaw contours.

Depending on the defect situation, the bone core harvested with this minimally invasive method can successfully regenerate significant bone defects with long-term stability[9] and provide a high level of function and aesthetics with appropriate soft-tissue management. The bone core technique is also suitable for incomplete regeneration after extensive augmentation using the shell technique. Depending on the regenerative capacity of the recipient region, incompletely regenerated areas can be re-augmented three months after augmentation by harvesting a bone core during implant placement.









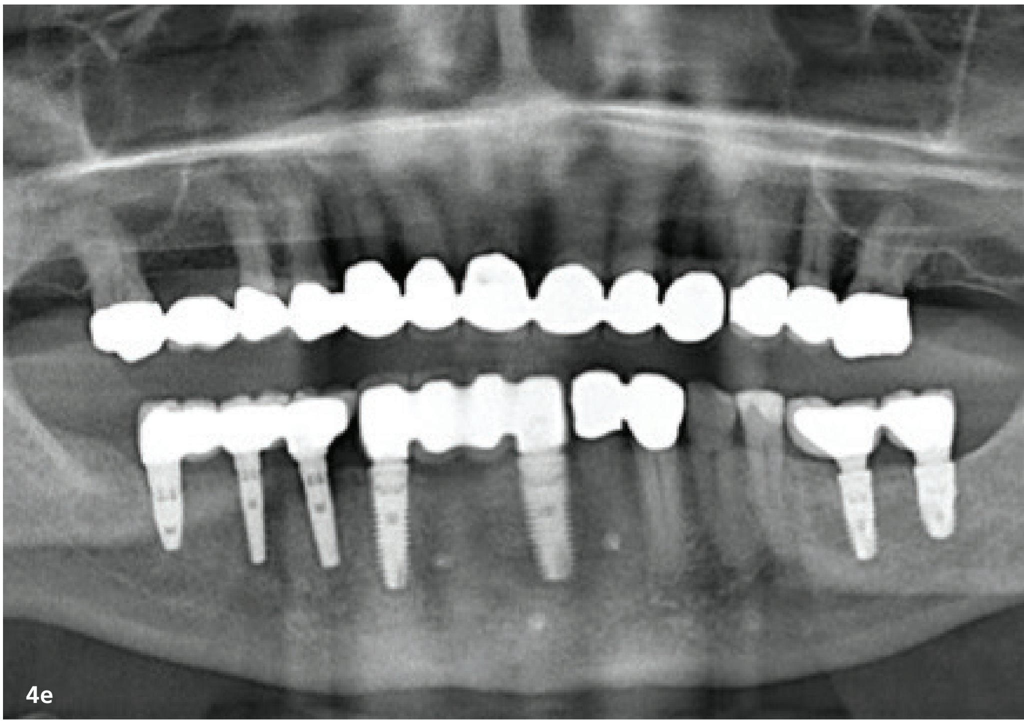


Fig. 4a: Non-ossified extraction site 43 and 2 mm of narrow alveolar ridge at site 31. **Fig. 4b:** Implant placement with exposed threads within the bone envelope at site 43 and simultaneous three-dimensional augmentation using the shell technique at site 31-32 by harvesting bone blocks from the chin region. **Fig. 4c:** Augmentation at site 43 using bone cores. **Fig. 4d:** The former bone defect is completely regenerated. **Fig. 4e:** Panorama radiograph after delivery of the final restoration.

Discussion

Various techniques and materials can be used to augment and reconstruct alveolar ridge defects. Clinical relevance depends on an overall surgical approach, supported by the use of techniques appropriate to the defect constellation.

Autologous bone is still the gold standard because of its biological advantages in different defect sizes, especially for extensive horizontal or vertical bone augmentation. Vital osteocytes and osteoblasts express bone morphogenetic proteins (BMPs) and stimulate the formation of mesenchymal stem cells, which in turn differentiate into osteoblasts and serve as initiators of regeneration.[9,18]

The shell technique with mandibular bone grafts (split bone block technique) is a proven autologous augmentation technique for the reconstruction of vertical and lateral defects. However, the shell technique requires a second surgical site. For smaller bone defects, a less invasive solution using autologous bone is preferred.[15,19–21] In the bone core technique, depending on the defect morphology, the bone required for lateral and vertical augmentation can be harvested by primary trephine drilling from the area of the implant bed alone. The bone mass removed during the preparation of the implant bed is therefore not lost, but effectively utilised and then secured in the form of a drill core in its position at the recipient site with microosteosynthesis screws.[9]

A key advantage is that the use of autologous bone eliminates the need for membranes or bone substitutes from other sources, significantly reducing the risk of postoperative infection due to membrane exposure. Non-resorbable membranes are more susceptible to early exposure because of their reduced adhesion to surrounding tissue and are therefore often a source of contamination.[9,13]

The regenerative capacity of the autologous graft depends largely on the method of harvesting and the donor site.[22,23] Minimally invasive harvesting of a bone core in the bone marrow region is characterised by a thin, comparatively small cortical portion and a larger portion of cancellous bone.[24] This type of bone favours rapid revascularisation and is characterised by a high cellular content, increased differentiation capacity with formation of mineralised tissue and high expression of osteoinductive proteins (BMP-2 and VEGF).[25,26]

A prospective five-year study using the carrot technique in 186 patients with 223 augmented sites showed not only a high success rate but also long-term stability of the primary result.[2] Only 1.4% of treated patients (all smokers) showed minor postoperative complications, such as premature exposure of the implant cover screw, microosteosynthesis screws or parts of the bone core (< 2 mm). Considering the data published in the literature, the complication rate of the bone core technique is significantly lower compared to other augmentation techniques.[27–30]

In addition, the prospective study showed low bone resorption at augmentation sites within the bone envelope at the time of implant re-entry. Low resorption was observed in portions of the bone core that were located outside the bone envelope (Figs. 4a–e). The average width of the augmented area was 2.4 ± 0.8 mm at the end of surgery and 2.1 ± 0.6 mm at the time of re-entry at three months. Similar results were observed with the shell technique or bone splitting.[9,15,31] Radiological control examinations, including conebeam computed tomography (CBCT), showed stable peri-implant bone conditions during observation periods of between five and eight years, which is in line with the clinical results described above. No implant was lost over the entire observation period.[2]

Although the presented method is a good and feasible technique for the treatment of limited bone defects, complications may still arise due to bone overheating with the trephine bur in bone with a high percentage of cortical tissue, resulting in symptoms "burned-bone syndrome".[16] In the present study, such radiological findings were seen in two patients and successfully treated using a bony lid approach and removal of apical granulation tissue.[2]

Conclusion

The bone core technique is suitable for minimally invasive augmentation of specific bone defects using locally harvested bone. Gentle handling of the two-part trephine and the harvested bone core is essential for successful treatment with this technique. The bone core technique is cost- and time-efficient for both the patient and the surgeon and is characterised by its excellent biological and immunological competence. As an augmentation technique that is easy to integrate into daily practice, it offers low complication rates in addition to reduced treatment time and, in combination with adequate soft-tissue management, shows long-term stable results even in aesthetically demanding areas.

Literature

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