A Novel Type of Dental Tube Implant for Areas with Limited Bone Height. Clinical and Radiographic Data from Three Patients with 5-Year Follow-Up

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ABSTRACT

Background: Alternative implant designs may reduce the need for complicated and costly bone augmentation procedures in situations with limited bone height.

Purpose: Wide dental tube implants have been manufactured and tested in three patients and followed for 5 years to evaluate if such implants are capable to support fixed prosthetic constructions with good prognosis in areas with limited bone height.

Materials and Methods: Four machined-tube implants with a height of 6 mm, an outer diameter of 7.4 mm, and an inner diameter of 6.0 mm were placed in three patients. After a healing period of 3 months, ceramometal suprastructures were constructed to supply the implants. Annual clinical and radiographical follow-ups were done up to 5 years. At the 5-year follow-up, all three patients were examined with a cone beam computed tomography technique.

Results: All implants and the suprastructures were clinically stable after 5 years. In one patient, vertical bone loss and a 6-mm deep pocket appeared after 1 year. The pocket has remained throughout the observation period and has been regularly debrided and kept it free from clinical signs of inflammation. In the other two patients, the soft tissue surrounding the implants was in good health with no or only slight inflammation throughout all observations. Pocket probing revealed no or slight bleeding and pocket depths amounting to less than 3 mm.

Conclusion: It was shown that this new type of implant will function excellent during follow-up times of several years. Further studies should be done to explore in more detail indications for such implants.

KEY WORDS: case report, follow-up, implant, limited bone height

INTRODUCTION

The first systematic treatment with oral implants, which started in the 1970s, comprised both compact and hollow cylinders (tubes) with or without external threads.[1–7] The idea behind the use of hollow cylinders (threaded or not) was to increase the contact area between the bone and the implant enhancing the supporting capacity of the implant-bone unit. This may allow short hollow implants with about the same capacity as longer compact implants to successfully carry the superstructures. Further, the amount of bone tissue that has to be removed in connection with the implant installation will be considerably smaller as a trephine track only would be needed to place the implant.

Some problems and questionable benefits have, however, been reported with the initially launched hollow implants.[8–10] Firstly, the mantle wall had penetrating holes to enable connection between the bone tissue surrounding the implant and the bone tissue inside it. This meant that the tissue, both hard and soft,

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growing into and through the holes located close to the implant neck often was contaminated by the microflora of the oral cavity resulting in infection, not only outside but also inside the implant. Such an infection site is not easy to reach and cope with by local curable measures. Secondly, the benefit of increasing the bone-to-implant contact area using hollow implants with an outer diameter of only 3–4 mm might be questioned as the small inside surface area of such narrow implants does not contribute essentially to an enhanced retention surface. In addition, the tiny central bone pillar left after drilling with the trephine often might break and complicate the surgical procedure. The hypothesis behind holes was that the bone pillar inside the implant had to stand in contact with the bone tissue outside the implant to keep the bone pillar vital and avoid its resorption.

A series of animal studies has, however, demonstrated that also in compartments (e.g., hollow cylinders/tubes) with compact walls on all sides but one (usually the innermost), the inside bone will be kept intact. In fact, such a compartment may, due to continuous bone generation, be more or less filled with bone after some time even if it is empty at the time of implant installation.[11–16] This means that the implant might be placed in a position where its ceiling is located above the bone crest and still be more or less filled with bone appositionally grown and, above all, grown along the inner surface of the wall to increase the contact area between the implant and the bone. These findings are important to apply when there is place for a wide but short implant. If not only the external, but also the internal wall surface, is threaded, the bone-to-implant contact area is further increased. The wide tube implant would be especially suitable to place in areas with wide bone to support premolar and molar crowns, because it will not only effectively take up both vertical and lateral forces but also harmonize with the outer cervical tooth contour of these teeth. Hämmerle and colleagues showed in short-term human experiment that it was possible to form new tissue within a tube implant placed supracrestally.[17] However, the fill was hourglass-shaped with no bone contact with the inner wall of the implant. No human studies are yet available regarding long-term follow-up of tube implants in the clinical setting.

The aim of this study was to present three patients supplied with a novel type of hollow cylinder/dental tube implant followed clinically and radiographically for 5 years.

MATERIALS AND METHODS

The study protocol was approved by the Ethical Research Committee at Linköping University, Sweden (Dnr M143-08). All patients were thoroughly informed of the novel implant and the treatment procedure, and gave an oral and written informed consent to participate in the study.

Implants

All implants were fabricated from commercially pure titanium (grade 4) by turning and milling. The implant has an outer diameter of 7.4 mm and an inner diameter of 6.0 mm. The mantle wall thickness is 0.7 mm, as measured from the top of the outer self-cutting threads, which have a height of 0.3 mm and an edge-to-edge distance of 0.6 mm.

The height of the outer threaded area is 6.0 mm while the inner height of the implant is 5.0 mm at the mantle surface and 6.0 mm in the central area due to the conical shape of the ceiling. The outer marginal part of the implant has a 1.5 mm high turned area with no threads. This area, which is slightly tapered in occlusal direction, is intended to be suprabony located and ends up with a horizontal shelf surrounding a central hexagonal tower to retain a crown or a bridge anchor.

Surgical Procedure

Under local anesthesia, a full-thickness flap was raised to disclose the bone for preparation. In addition to regular instruments used for implant installation, a specially designed trephine was used to mill a track in the bone to retain the implant. The dimension of the trephine is such that the resulting circular slit permits the self-cutting implant threads to shear the slit of its outer wall, while its inner wall (i.e., the bone pillar) is left untouched. Using a trephine with an outer diameter corresponding to the outer diameter of the implant and an inner diameter 0.2 mm smaller than the inner diameter of the implant (i.e., with a wall 0.2 mm thicker than the implant wall), a 6-mm deep track was produced as measured from the bottom of the track to the highest level of the crest. The inner diameter of the trephine was chosen to avoid turning the central bone pillar loose during the threading. The insertion of the implant was made using a driver with an internal hex that fitted to the external hex of the implant tower. The implant was screwed in place until it felt seated. The soft tissue was adjusted to the implant neck using a punch and then

sutured after which, a cover screw matching the tower and its shelf was placed. The patients were advised to refrain from toothbrushing in the operated area and instead rinse with a 0.1% chlorhexidine solution (Hexident, MEDA, Solna, Sweden) twice daily until removal of the sutures. Thereafter, they were instructed to clean the implants with a soft toothbrush together with a 1% chlorhexidine gel (Corsodyl, GlaxoSmithKline, Malmö, Sweden). After a healing period of 3 months, ceramometal suprastructures were constructed to supply the implants (see later section).

Patient 1. A 56-year-old, healthy woman, fully dentate in the maxilla but missing the second premolar and molars in the right mandible. One tube implant was placed in the second molar area immediately above the mandibular canal (Figure 1). In a second operation, two conventional 7-mm Brånemark implants (Nobel Biocare, Göteborg, Sweden) were installed in the first molar and second premolar area. After 3 months of healing, the implants were connected in a three-unit, screw-retained bridge.

Patient 2. A 52-year-old, healthy man with advanced periodontal destruction at the first premolar and molar. These teeth were extracted during periodontal treatment. A conventional Brånemark implant was installed in the premolar area while a tube implant was installed in the molar area. In this site, the bone height was extremely low, especially in the distal part (Figure 2) so that the apical part of the implant became placed within the right maxillary sinus. The bone pillar in the area

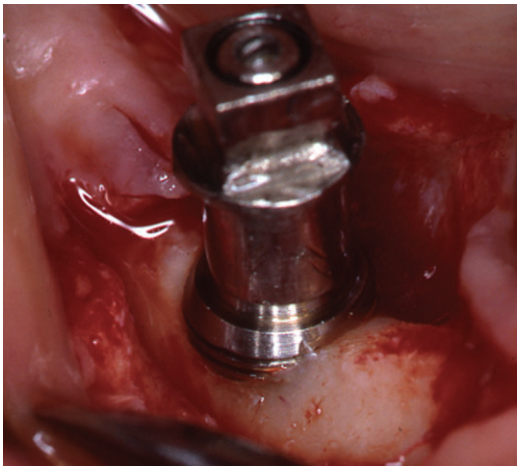

Figure 1 Patient 1. Tube implant installed in the mandibular first molar area. Note exposed threads buccally.

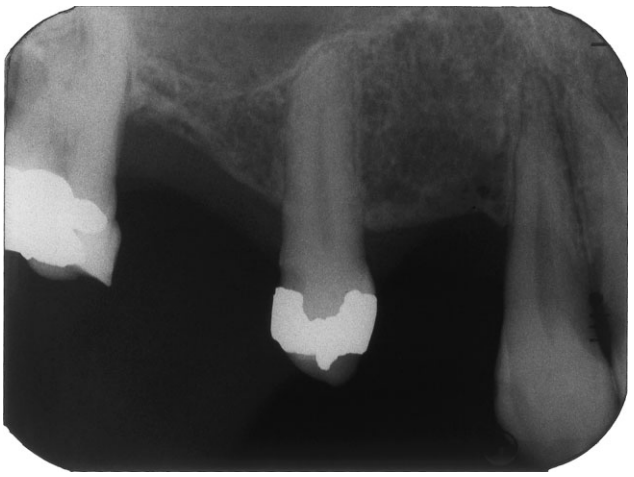

Figure 2 Patient 2. In the molar area, the bone height is extremely low, especially in the distal part.

became loose during drilling and was dislocated into the sinus cavity, however, without obvious sign of perforation of the sinus membrane. The tube implant was supplied with a screw-retained crown while the conventional implant received a cemented crown.

Patient 3. An essentially healthy 68-year-old woman, fully dentate in the mandible but missing the molars in the left maxilla. Because of periodontal disease, both premolars were lost in this quadrant. A relatively large maxillary sinus limited the bone height to about 6–8 mm (Figure 3) while the marginal bone width was about 8–9 mm slightly below the top of the crest. After flap elevation, two suitable areas for installation were marked with a small round bur with a center-to-center distance of about 9 mm and two tube implants were installed.

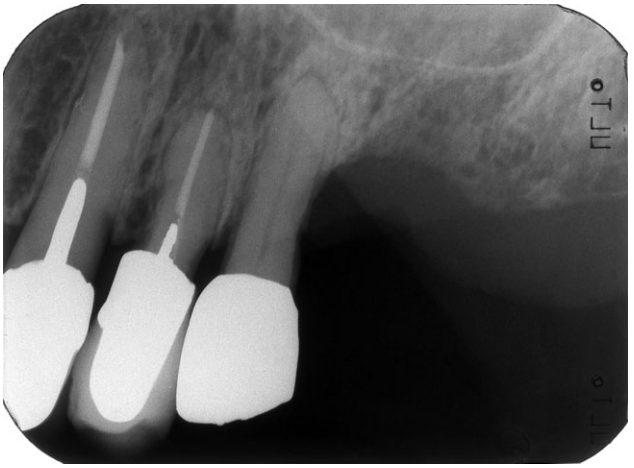

Figure 3 Patient 3. Due to periodontal disease, both premolars were lost. A relatively large maxillary sinus limited the bone height to about 6–8 mm.

A conventional Brånemark implant was later installed in the first premolar area. After healing, the crowns were soldered together with a crown on the conventional implant to form a screw-retained three-unit bridge.

Postoperative Follow-Ups

Intraoral radiographs were taken to show baseline data of bone support, and clinical photos were taken to show the level of soft tissue margin and status of the oral mucosa. Pocket depth and attachment level were measured at all surfaces of the implants. The clinical parameters were registered at 6 months, 1, 2, 3, and 5 years, while radiographs were retaken at 1, 2, 3, and 5 years. At the 5-year follow-up, all three patients were examined with a cone beam computed tomography (CBCT) technique (3D Accuitomo MCT-1, EX-2F8, J Morita MFG Corp. Kyoto, Japan, imaging field of view 40 × 40 mm or 60 × 60 mm) in the implant areas.

All prosthetic constructions (superstructures) were unscrewed at the yearly follow-ups to check the stability of the individual implants by percussion. Between these appointments, clinical inspections were made on an individual basis to control that home care and soft tissue conditions were up to standard.

RESULTS

All tube implants were clinically stable 5 years after installation. In patient 1, a vertical marginal bone loss along the distal surface appeared at the adjacent conventional implant 1 year after installation. This implant was later removed. During follow-up, a 6-mm deep pocket with bleeding on probing was found at the buccal aspect of the tube implant. The pocket has remained throughout the observation period and has been regularly debrided and kept it free from clinical signs of inflammation. In the other two patients, the soft tissue surrounding the implants was in good health with no or only slight

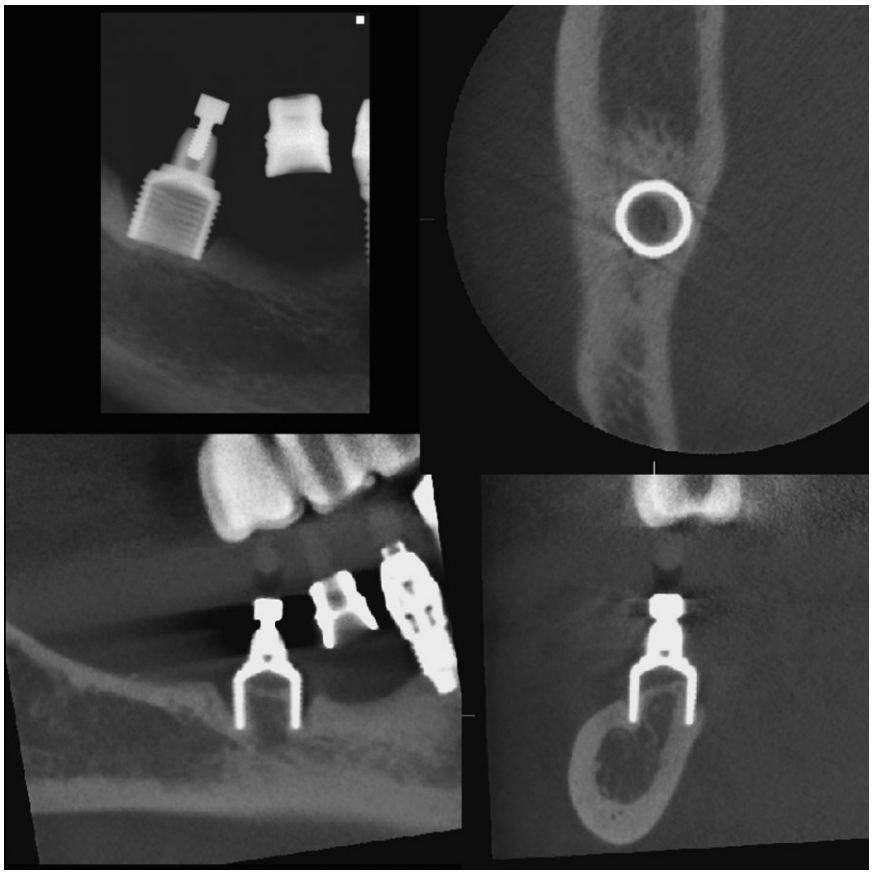

Figure 4 Patient 1. Composite image of intraoral radiograph and CBCT images in axial, sagittal, and cross-sectional views of the tube implant in lower right molar area, 5 years after implant insertion. The bone fill inside the tube amounts to 80–90%, a level that is higher or much higher than outside the tube. Implant-bone contact area is on average two to three times larger inside compared with outside the tube. (CBCT = cone beam computed tomography.)

inflammation throughout all observations. Pocket probing revealed no or slight bleeding and pocket depths amounting to less than 3 mm. All three patients showed an excellent plaque control throughout the study.

The radiographic examination with the CBCT technique 5 years after implant installation showed that there were different bone-to-implant contact patterns for the three patients. In the following, each one is described in context with the detailed presentation of each case.

Patient 1 (Figure 4)

The outer marginal bone level is located between the middle height and the apical third of the implant at buccal and lingual surfaces. The bone loss is more pronounced at the proximal surfaces. The coronal (top) surface of the bone inside the tube is located 1–3 mm apical to the ceiling of the implant and above the level of the outer bone surface. Because of fear for interference with the mandibular nerve, the implant was placed more coronal than optimal (see cross-sectional image), leaving two threads exposed buccally (Figure 1).

Patient 2 (Figure 5)

The marginal bone level in contact with the external implant surface is located about 1–2 mm apical to the unthreaded area of the implant. There is no bone but soft tissue inside the implant. The inferior border of the maxillary sinus is lacking and a mucosal swelling is seen.

Patient 3 (Figure 6)

The outer marginal bone level in contact with the implants is located approximately 2–3 mm apical to the unthreaded area of the implant, which is also confirmed in the intraoral radiographs. The coronal (top) surface of the bone inside the tubes is located close to but not in direct contact with the ceiling/inner roof of the implant. The bone fill is about 90% of the internal implant volume.

DISCUSSION

The overall treatment, including implant placement, was uneventful, except for patient 2, with no complications and well-accepted by the patients. In patient 2, the remaining bone at the intended implant site had such inadequate height that it became loose during implant

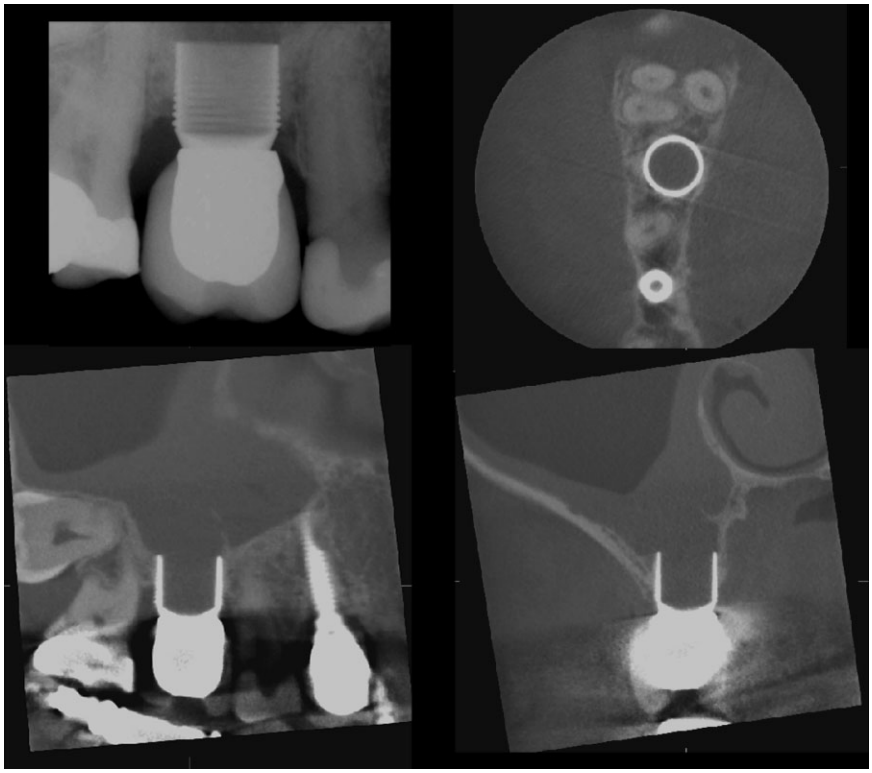

Figure 5 Patient 2. Composite image of intraoral radiograph and CBCT images in axial, sagittal, and cross-sectional views of upper right first molar tube implant, 5 years after implant insertion. There is no jawbone, but sinus membrane soft tissues inside the entire tube. The implant-bone contact area outside the tube varies from 50–100% of the mantle wall height.

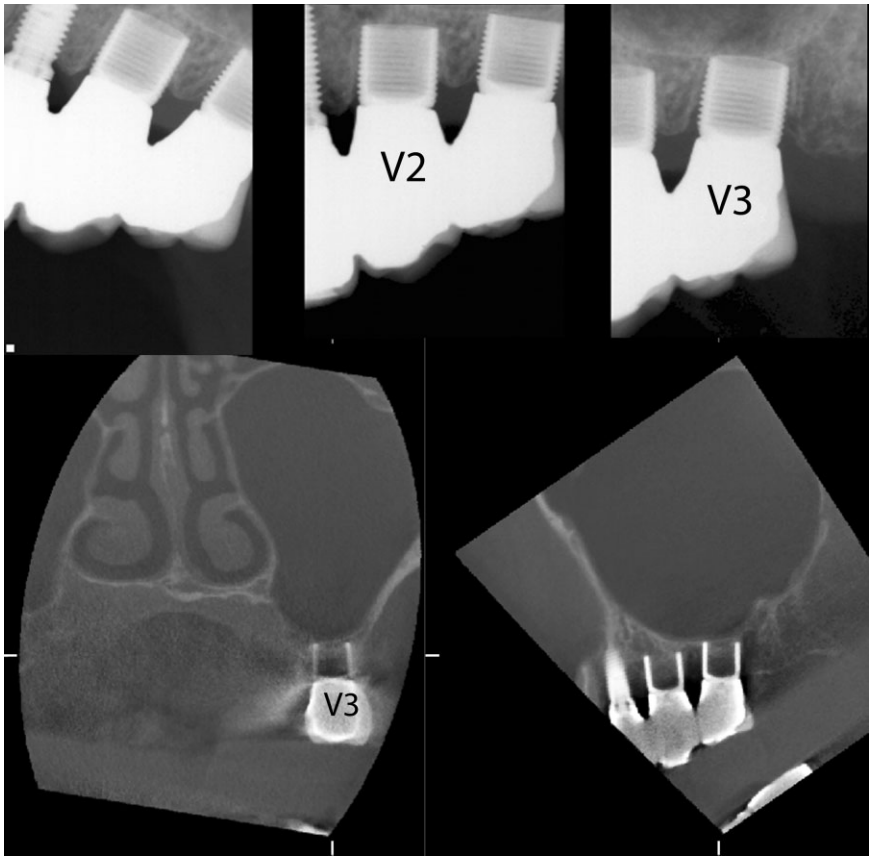

Figure 6 Patient 3. Composite image of intraoral radiographs and CBCT images in axial, and cross-sectional (V3), and sagittal (V2, V3) views of two tube implants in upper left premolar molar area, 5 years after implant installation. There is about 90% of bone fill inside the tubes and only slight to minor marginal bone loss outside the tube walls.

placement. An alternative treatment modality would have been the insertion of short "conventional" implants, 3–4 mm in diameter. However, as the bone height was limited, a larger number of such implants would have been demanded, implants, which do not harmonize neither with the bone width nor with the crown width.

In patients 1 and 3, contact between the implant wall and the external, as well as the internal, bone tissue was obviously maintained throughout the entire observation period of 5 years (Figures 4 and 6). In patient 2, the external surface of the implant maintained contact with the adjacent bone throughout the study, while the initial small amount of internal bone tissue disappeared and became replaced with soft tissue (most likely sinus mucosa) (Figure 5). Recent reports have demonstrated osteogenic capacity of cells in the sinus membrane.[18–20] However, in this case, no new bone was formed inside the implant, neither by the remnants of bone tissue entrapped nor by the sinus membrane. The external bone tissue did, however, survive to integrate with the external surface of the mantle wall of the implant.

Thus, all implants became osseointegrated – a status which was maintained for the observation period of 5 years. The fill-out of bone tissue inside the implants in patients 1 and 3 means that the bone-to-implant contact area became roughly twice that would have been the case for correspondingly sized compact implants. The consequence of this larger contact area can only be speculated upon, but it is reasonable to suggest that the capacity to carry a superstructure is increased meaning that a much lower bone height would be accepted compared with an implant permitting contact with external bone only.

Another interesting consequence of the tube cylinder design is that a stepwise or continuous breakdown of the external marginal bone over time because of infection (plaque accumulation) even down to the deep parts of the implant (patient 1) will not necessarily result in loosening of the implant as the bone-to-implant contact area inside the implant might as well be sufficient to

retain it. Another clinical benefit when installing tube implants compared with compact implants is the reduced amount of bone that has to be removed, which will simplify the surgical procedure. Whether the increased bone-to-implant contact also will influence the tactility during chewing and biting is another interesting issue to explore.

If the inner compartment of the tube implant is only partly filled with bone, there will be no direct contact between the inner top surface of the implant and the top surface of the internal bone. This may be interpreted as if there will be no strict vertical support from the top bone surface inside the implant, but support by shear forces from the implant walls only. However, in such a situation, the inner compartment adjacent to the ceiling and above the inner bone will contain exudate, which will transfer the force from the ceiling to the top bone surface and then roughly will serve the same function as if there was a direct bone-to-implant contact.

The tube implant design takes advantage of the available lateral bone and requires a minimum of bone height. It has, however, to be kept in mind that the dimension of the tube demands sufficient bone width to reach full coverage of the implant. In addition, considerable clinical experience and skill with implant surgery is needed due to the obviously different surgical protocol.

CONCLUSION

It can be concluded that the installed wide tube implants used in this clinical study healed in successfully and were capable to support their superstructures. The adjacent soft and hard tissue contacts with the implants were maintained healthy with no major changes during the follow-up period of 5 years. This type of implant can successfully be used in areas with extremely reduced bone height but generous bone width without need for complicated and costly bone augmentation procedures.

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