Biologically based implant surface designs enhance bone formation

The Influence of Surface Designs on Implant Integration

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Dental implants have become a common treatment modality in edentulous patients and in patients where the preparation of healthy teeth for fixed restorations can and should be avoided. Investigations have focused on the ideal prerequisites for increasing the rate of bone accumulation at the implant surface to shorten the healing period and to support the long-term success of the restoration. In critical clinical situations – including immediate-insertion cases, sinus floor elevation or insufficient bone height or width – a sufficient number of implants is needed to ensure osseointegration and long-term success [1-3].

Materials and methods

Animal model
The study was carried out in two female beagle dogs in a split mouth design. Two beagle dogs were obtained from the department of animal studies of Virchowklinikum Charité, Berlin/Germany. The dogs had complete dentitions and weighted about 11 kg.

The surgical procedures were as follows: The dogs were first sedated (Trapanal, 10–15 mg/kg i.v.). The future implant sites were then prepared under general anaesthesia (60% N2O, 40% O2, 1.5% isoflurane) by reflecting mucoperiosteal flaps and atraumatically extracting the mandibular third and fourth premolars in both sides of the lower jaw.

Three implants (10 mm in length, 4.1 mm in diameter) were immediately placed in each lower quadrant using either a test-control-test sequence or a control-test-control sequence (Fig. 1).

Fig. 1 Patterns of implant insertion.
The mucogingival flap was mobilized to ensure complete closure of the wound and sutured with single stitches (Vicryl, 4-0). The dogs received an analgesic (0.3 g of metamizole/Novalgin) immediately after surgery, followed by an additional dose the next morning and evening mixed into their food. The animals were put on a soft diet for seven days and then returned to their normal hard-pellet diet. Tooth cleaning was undertaken daily for the whole three-month period, applying 0.12% chlorhexidine solution with a cotton swab. After three months of healing, four implants (one control implant, three test implants) were removed by block resection without sacrificing the dogs, using the same protocol as for the surgical procedure described above. Following the preparation of the mucoperiosteal flap, alveolar bone containing the implants was separated from the remaining bone using a Lindemann bur. The implants were then analyzed histologically (Fig. 2).

**Histological analysis**

Tissue blocks were placed in 4% formaldehyde for fixation, dehydrated in graded alcohol series and embedded in MMA (methylmethacrylate). Tissue blocks were secured in place on a microtome and cut into sections of less than 20 µm. Buccolingual sections were cut through the central portion of each implant. Sections were evaluated by a light microscope (Leitz, x 17.5 magnification) linked to a Vario-Orthomat for taking pictures.

**Results**

Twelve implants were placed in all. The implants were removed by block resection after three months of healing. Four implants were used for further histological evaluation. Sections from one control and three test implants were analyzed. As seen under the light microscope, the test implants showed more bone-to-implant contact across the entire implant surface than the screw-type control implant. Less bone formation was observed within the thread grooves of the screw-type implant (Figs. 3 and 4).

**Discussion**

Our promising preliminary data from the present pilot study carried out on two beagle dogs support the idea that biologically based surface characteristics enhance bone formation.

A systematic review of the incidence of biological and technical complications in implant dentistry demonstrates that implant loss prior to functional loading occurs in 2.5 percent of the cases. About 2 to 3 percent of the implants supporting fixed structures and more than 5 percent of the implants supporting overdentures are lost during function within the first five years [12]. Few data are available concerning the success rates for immediate implant placement and augmentation procedures [13, 14]. In a systemic review, Berglundh and co-workers report implant loss before loading in immediate placement/early loading procedures in 3.25 percent of the cases, and 7.47 percent when augmentation was performed [12].
One clinical prerequisite is the fact that the implant system has a high success rate even in critical situations, e.g., immediate insertion and compromised bone. We might speculate that the macroscopic and microscopic surface design of biologically based implants—such as bipsystems implants—induce faster and stronger integration of the implant into the alveolar bone. Rhombic grooves the size of osteons show higher bone-to-implant contact after three months of healing than screw-type implants. Visualized by light microscopy, screw-type implants exhibited less bone formation, especially within the grooves of the thread.

More in vivo and in vitro studies with greater numbers of implants are needed to confirm our preliminary data and to obtain statistically relevant data. Regarding our preliminary data, we can speculate that biological bonding as a result of biologically based surface characteristics as seen in bipsystems implants might satisfy the clinical claims for immediate implantation and long-term success.

References
