I. I. Ilizarov was the first to describe the technique of callus distraction in orthopedic surgery. Distraction of the alveolar ridge was first used by Chin and Toth and Block et al. This technique is based on secondary osseous wound healing. Chin and Toth mostly treated patients with alveolar ridge defects after trauma. Other authors have described a similar technique for distraction of the edentulous mandible.

Since 1997, a newly developed distraction system that remains in the alveolar ridge after distraction and can be included in the prosthetic treatment has been in use. The distractor is designed as a dental implant. After osseous healing, the distraction implant is transformed into a permanent implant by changing the head of the distraction device to load it with prosthetic superstructures. Thus, single-crown restorations, fixed partial dentures, and removable overdentures can be incorporated.

The purpose of this clinical evaluation was to describe the advantages and outcome of prosthetic treatment of distraction implants.

**Purpose:** The purpose of this study was to clinically evaluate the mucosal condition and the esthetic and functional results of distraction implants loaded with fixed or removable implant-supported restorations. **Materials and Methods:** A total of 35 patients were treated with 62 distraction implants for correction of alveolar ridge deficiency. The distraction implants were loaded with prosthetic superstructures 4 to 6 months after distraction. Nine patients were provided with single-crown restorations, 16 received metal-ceramic fixed partial dentures, and 10 received removable overdentures. Recall was scheduled before and 3, 6, and 9 months after implant loading. Periotest values, perimplant probing depths, and radiographic marginal bone levels were recorded, along with any biologic or mechanical complications. **Results:** Patients were followed for 9 months after implant loading. Two distraction implants were lost before abutment connection. After fabrication and placement of individual abutments, all implants were loaded with prosthetic superstructures. The results showed a decrease of the Periotest values, and thus an increase of implant stability, during the following 9 months. Perimplant probing depths also decreased in the first months after implant loading. Soft tissue around the superstructures and adjacent teeth was healthy. **Conclusion:** The distraction implant system has a high potential for osseointegration. Because of the gentle distraction technique and the possibility of using individual abutments at almost any angulation, satisfying esthetic and functional results are possible. The rate of complications was low in this short-term study.
Materials and Methods

Implant Design

The DISSIS distraction implant (SIS Trade Systems) is a self-cutting conical screw implant made of medical grade 4 titanium. By activation of a central distraction screw, it can be elongated 6 mm (prototype one) or 10 mm (prototype two). If the implants are placed in combination with a segment osteotomy, the bone can be distracted by this device. After the end of the distraction procedure, the distraction implant is transformed into a combined screw and cylinder implant and can be used for prosthetic loading later (Figs 1 and 2).

Surgical Procedure and Distraction Protocol

Since 1997, 35 patients have been treated with distraction implants for vertical distraction of the alveolar ridge. Among the patients, seven showed severe atrophy of the edentulous mandible, three had severe atrophy of the maxilla, 16 had severe alveolar ridge defects after trauma, and nine had localized alveolar ridge defects after single-tooth loss. The mean age of patients with atrophy was 60 years, the mean age of patients with extended defects was 34 years, and the mean age of patients after single-tooth loss was 22 years.

The surgery was performed as a segment osteotomy followed by placement of distraction implants (Fig 3).
In patients with severe atrophy of the edentulous mandible, two distraction implants were placed in the interforaminal area. In patients with severe atrophy of the edentulous maxilla, two distraction implants were also used in the anterior maxilla. The osteotomy was carried out as a sandwich osteotomy. Patients with severe alveolar ridge defects were also treated with two distraction implants. Only one implant was used in patients with single-tooth loss.

After a healing period of 7 days (alveolar ridge defects) to 10 days (alveolar ridge atrophy), distraction was started by activating the central distraction screw. Distraction was continued for 8 to 24 days to achieve an increase in the alveolar ridge height of 4 to 6 mm. The distraction was carried out at a rate of 0.25 mm (alveolar ridge atrophy) to 0.5 mm (alveolar ridge defect) per day. After the planned distraction height was achieved, the distraction insert was replaced by the definitive implant insert. Six patients with alveolar ridge atrophy and nine patients with alveolar ridge defects were further treated with conventional dental implants 6 weeks following the distraction. Before prosthetic treatment was started, these implants and all distraction implants healed for 4 months (alveolar ridge defects) to 6 months (alveolar ridge atrophy). The distraction protocol is demonstrated in Fig 4.

**Prosthodontic Procedure**

The prosthetic treatment started when Periotest (Siemens) values ranged in the physiologic area (between +3 and −3). After each single implant was provided with a transmission device, the impression was performed with a polyether impression material (Impregum, ESPE). Then, plaster cast models with laboratory implants were prepared. Depending on the angulation, either individual or straight abutments were used.

When manufacturing straight abutments, a prefabricated abutment was first fixed to the laboratory analogue. Afterward, the high-melting alloy (HMA) base ring was put over the implant head. This base ring can be connected to any individually waxed-up crown (Fig 5). Then, the metal frame for a crown or permanent partial denture was made. Further bar superstructures can be made. Angulated abutments are also based on prefabricated base elements. In this case, the abutment is produced with individual angulation by the dental technician and fixed by a central screw to the laboratory analogue. Disparallelism between the implants can be corrected with the help of a parallelization device. In this case, the HMA base ring also serves as a basis for the waxup of the crown.
The superstructures were temporarily incorporated after completion. In cases of edentulous patients, the implants were loaded with a rigid bar and a removable prosthesis. Except for single crowns, a test period of 2 weeks was scheduled with all superstructures. Thirty-four patients were provided with prosthetic superstructures after distraction. Patients with single-tooth loss were provided with metal-ceramic crowns. Eleven permanent partial dentures and five connected crowns could be incorporated (Fig 6). Patients with atrophy of the edentulous mandible or maxilla were provided with removable overdentures. The implants were connected with a rigid bar.

Maintenance was scheduled before and 3, 6, and 9 months after implant loading. Periotest values, peri-implant probing depths, and radiographic marginal bone levels were recorded, along with any biologic or mechanical complications. The Periotest was carried out five times after removal of the superstructure, and the mean was noted. Perimplant bleeding was observed according to the sulcus bleeding index suggested by Mühlemann and Son.11 Perimplant probing depth was measured at four locations for every implant (mesial, distal, buccal, and oral); the greatest value was registered. For radiographic follow-up, panoramic radiographs and dental radiographs were used, and the rate of periimplant bone resorption was registered.

**Results**

The clinical evaluation showed satisfying functional and esthetic results in 30 patients at every recall. During an observation period of 9 months, no superstructure was lost or loosened. Perimplant mucosal conditions appeared healthy. All prosthetic restorations revealed a desirable dynamic and centric occlusion.

Two distraction implants did not osseointegrate and had to be removed. Two patients with severe defects of the alveolar ridge had premature reunion of the fragments. Thus, distraction had to be stopped 1 mm before the planned distraction height could be realized. Since only a small persisting deficiency of the newly formed ridge remained, the distraction implants were used for prosthetic superstructures. The dental crowns were 1 mm longer in the cervical part than the adjacent teeth, but no further augmentative techniques were applied. In one patient, an overcorrection occurred and a cervically shorter crown resulted.

Sulcus bleeding was detected around four distraction implants before prosthetic treatment and in only one implant during all examinations after implant loading. In this patient, a vestibuloplasty and transplantation of mucosa was performed 8 months after implant loading. Probing depths were deeper than 3 mm in three implants before prosthetic treatment and for one implant during all examinations after implant loading. Before prosthetic treatment, Periotest values varied between +1 and –2. The values decreased during the first 9 months after implant loading (Fig 7). Radiologic evaluation showed a mean perimplant bone resorption of 0.3 mm at 3 months after distraction, 0.4 mm at 6 months after distraction, and 0.4 mm at 9 months after distraction.

**Discussion**

In the past few years, numerous augmentative techniques have been used in dental implantology to provide edentulous patients or patients with severe alveolar ridge defects with prosthetic restorations. These restorations did not result in satisfying esthetics and good masticatory function in every case.12 Nevertheless, alveolar ridge augmentation is necessary to achieve good results when dealing with bone loss in
the alveolar region. Autologous or allogeneic bone transplants can augment the local ridge, but they show a high degree of bone resorption. Sufficient expansion of the adjacent gingiva is not obtainable with these techniques. Therefore, various methods of callus distraction of the alveolar ridge have been developed to not only provide local bone growth induction, but also to allow elongation of the attached gingiva. By using distraction implants, a one-stage procedure for distraction and implant placement is achieved. The technique with distraction implants is new, and long-term results about stress tolerance and functional and esthetic outcomes are still lacking.

By using the described distraction system, a desirable outline of the marginal cuff was achieved. Additional scarring of the marginal gingiva was also avoided. It is important to recreate the natural look of the marginal gingiva. Therefore, it is crucial to use healing abutments before implant loading. In this study, the system’s healing abutments made it possible to already create periimplant soft tissue in the preprosthetic stage, with good esthetic results. No cases of periimplantitis were observed.

Component fracture and screw loosening are prevalent concerns with contemporary dental implants, mainly within the first year after implant loading. Two prosthetic concepts are in use when loading distraction implants. Desirable tooth esthetics are achieved by the possibility of using individually created prosthesis. Even unfavorable angularizations can be corrected with angulated abutments, and patients can be provided with satisfying esthetic and functional superstructures. The volume and quality of the jawbone is a crucial factor for positioning the dental implant within the dental arch. It is not always possible to place the implant anatomically correctly within the dental arch because of severe bone resorption. The direction of the distraction is of the utmost importance. Corrections in all three dimensions are often necessary. By using abutments with individually created angulation and design, nonoptimal implant positions can be corrected.

Creating an individual crown margin within the periimplant sulcus is a second and also very important factor. The success rate of endosseous implants also depends on the gap between restoration and abutment. Population of this gap with microorganisms could lead to periimplant infections, with subsequent bone loss. In patients with distraction implants, a low rate of periimplant bone loss and infection was registered. Using a prefabricated basis of the superstructure, a gap of less than 3 µm can be achieved. Thus, the incidence rate of periimplant infections was low. The HMA ring is put over the implant head and can be cast to every crown system. Therefore, this ring minimizes the gap between implant and crown and contributes to the stabilization of the gingival situation. Thus, ideal preconditions for a good esthetic outcome of the marginal gingiva are made. The result is a long-term stabilization of the marginal gingiva without any periimplant infections. Having the dental technician make the abutments parallel simplifies the incorporation of the superstructure.

Conclusion

The advantages of distraction implants are as follows. There is only a one-stage surgical procedure for
distractor and implant placement, with a low rate of complications and implant loss. A careful distraction technique results in a low grade of scarring and satisfying soft tissue esthetics. Using individual abutments also provides good hard tissue esthetics. The good perimplant conditions result in minimal postoperative bone resorption.

References