Mini-dental implants as strategic pillars for improved retention of partial dentures

Partial dentures supported by natural teeth are one of the standards in dentistry. Demographic change and preventive measures to save teeth contribute to decrease edentulism in older people. The importance of partial dentures, on the other hand, will increase to the same extent. As with full dentures, mini dental -implants with a reduced diameter can be used instead of conventional implants for partial dentures. In the following article, the authors describe the indications and the principles of implant-prosthetic treatment using mini-dental implants.

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Partial dentures supported by natural teeth are one of the standards in dentistry and represent a significant percentage of the prosthetic fittings of the German population.1A wide variety of retaining elements, from braces to telescopes, have proven their worth for the corresponding indication.2–3 The demographic change on the one hand and the increased use of preventive measures to save teeth on the other contribute to the fact that old and very old people will have partial dentition and the complete edentulism will decrease.4 The supply of partial dentures is of great importance for this population group, since a fixed supply on the natural teeth is often no longer possible and an implantological pillar augmentation for implant-prosthetic fixed solutions is often not feasible for financial reasons or because of the high effort, e.g. in the case of augmentations or if the associated health burden is out of the question.

Fig. 1

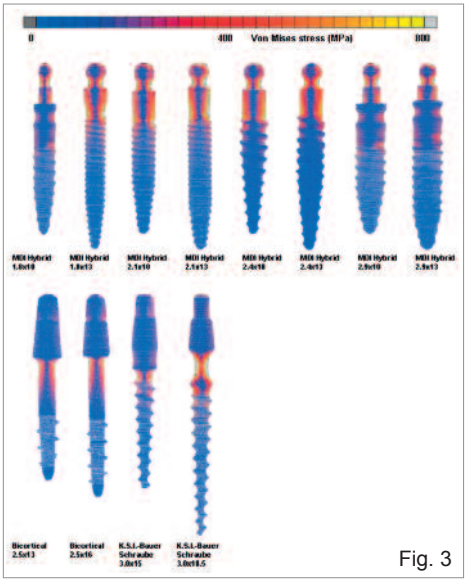

Fig. 3

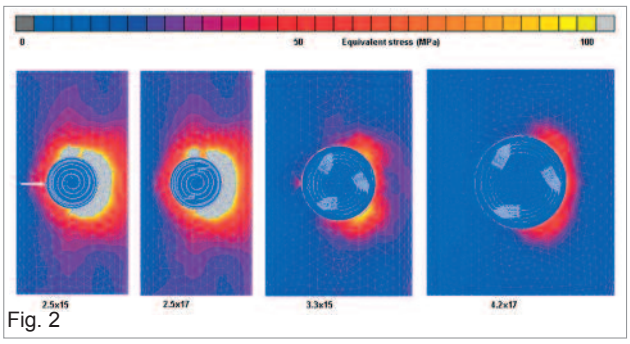

Fig. 2

Poor denture retention

However, many partial dentures lack retention - this is often related to the number and positioning of the remaining teeth. In particular, dentures that are used to treat free-end situations can often only be insufficiently attached to the natural tooth substance - regardless of whether this is done with braces or telescopes.5 Periodontal-gingival supported partial dentures become lodged in the mucous membrane when chewing, which puts more strain on the abutment teeth. In some cases, this leads to increased periodontal mobility.6 The lack of retention of the dentures is not only uncomfortable for the patient, but it also represents a risk for the abutment teeth, which can result in their premature loss.

Implants as additional pillars

According to studies, it is possible to increase the retention of partial dentures by inserting implants, which serve as

Fig. 1: Finite element model of a mini dental -implant, inserted into an idealized bone segment in the lower jaw anterior region. A force of 150N was applied to simulate biting. –Fig. 2: Overview of the cortical bone. The calculated stresses are colour-coded. The limit value of 100 MPa has been reached in the areas shown in yellow, while the limit load has been exceeded in the areas shown in grey. –Fig. 3: Colour-coded representation of the stresses in the implants with a transversal load of 150N. Overall, there does not appear to be any risk to the implants. Only the implant with a taper shows that the yield stress is exceeded in a larger area. While there is a risk of deformation here, the implant is also designed to be bendable.

additional abutments and reduce the stress on natural teeth.7–9 The more implants are used, the lower the load on each individual pillar. As with full dentures, mini dental implants with a reduced diameter can also be used with partial dentures instead of conventional implants.

These have been used successfully for more than 15 years, they are approved for long-term use, and they achieve comparable success rates to conventional implants for the stabilization of total lower jaw prostheses.10 However, the results of a current study indicate that with direct force transfer to mini dental -implants, a higher load acts on the surrounding bone than with conventional implants.11 With the concept for stabilizing prostheses with mini dental implants in mind (MDI, 3M ESPE Seefeld, Germany), for example, the force does not act directly on the implants, since the prostheses are supported by the mucous membranes and they are only retained by the implant thanks to a special prosthetic concept. In analogy to total dentures, mini-implants are indicated for patients who have reduced horizontal bone availability or who decide against conventional implant therapy for other reasons, such as medical or financial.

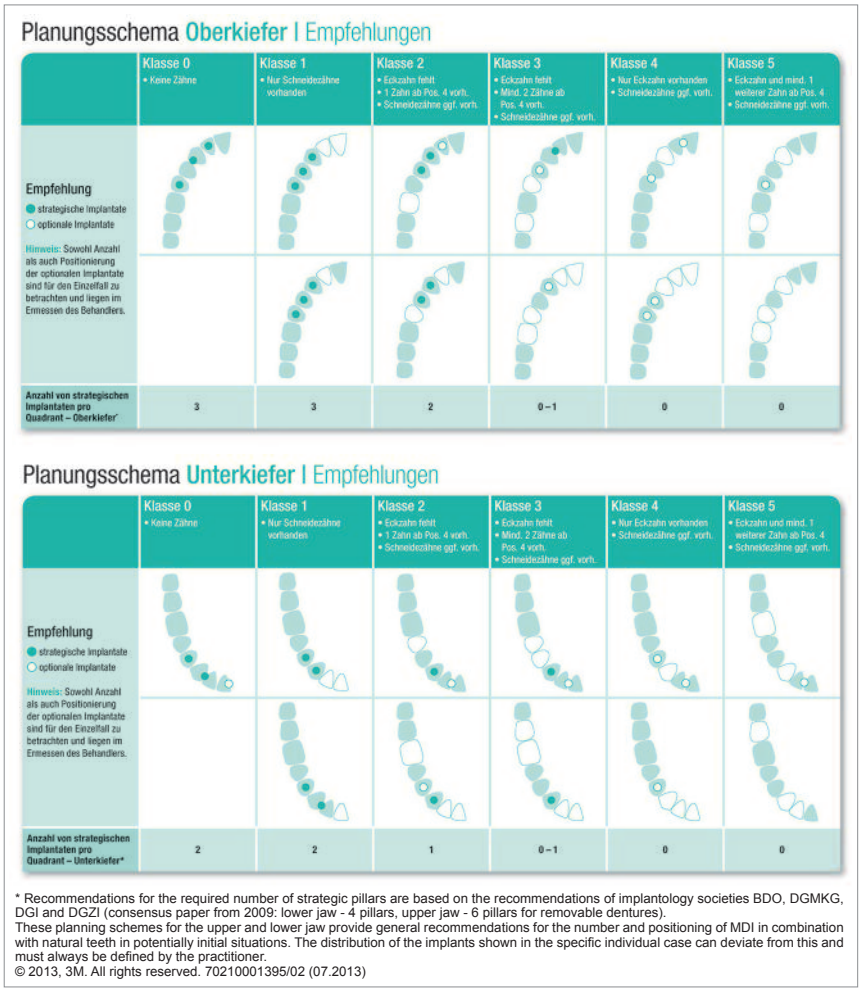

Fig. 4 and 5: Planning scheme for the correct positioning of mini dental implants in the upper and lower jaws.

Biomechanical Aspects

The suitability of mini-implants from a biomechanical point of view for solving such clinical problems has been proven in extensive experimental and numerical studies.11,12 For these investigations, among others, finite element (FE) models of mini-implants were developed, which were inserted into bone segments that are typical for these clinical situations. Figure 1 shows the FE model of a mini-implant with surrounding bone in an idealized geometry. A thin bone structure can be seen, which is typical for the edentulous lower jaw anterior region with a thick cortical bone and a reduced cancellous bone. The threads of the implant were modelled in order to be in contact with the cortex. The implant was loaded at an angle of 30° to the longitudinal axis with a force of 150 N to simulate biting in the anterior region. Such models were generated for comparison for various commercial and idealized mini-implants11,12 and compared with experimental studies on bovine ribs. The results predominantly showed bone loads in the physiological load range. For lesser diameters and lengths up to 15 mm, however, stress values above the physiological range were also detected if a transverse load at an angle of 15° was assumed. Figure 2 shows such a critical situation in a colour-coded representation of the stresses in the cortex around the mini-implants. The assumed limit value for the stress in the cortical bone is 100 MPa. In the case of the implant on the far left, this is exceeded over a large area. With increasing implant length, slightly larger diameter and vertical application of force, such overloads were limited to isolated cases. Nevertheless, this result makes it clear that the number of implants must be planned carefully if critical stress situations have to be taken into account. In borderline cases, the number of implants should be increased, in order to prevent excessive stress on the bone.

Another important result of the studies mentioned relates to the load on the implant itself. Figure 3 shows a number of FE models of commercial mini-implants, also colour-coded.

This time the scaling is selected so that the yield stress of the material (Titanium Grade 4 or 5) represents the upper limit of the colour scale. Overall, it could be determined that mini-implants are a suitable option for implant-prosthetic treatment from both a material-technical and a biomechanical point of view. However, in critical cases, the number of implants should be increased for safety. This is clearly proven by the bio-mechanical results. So far, however, only single implants

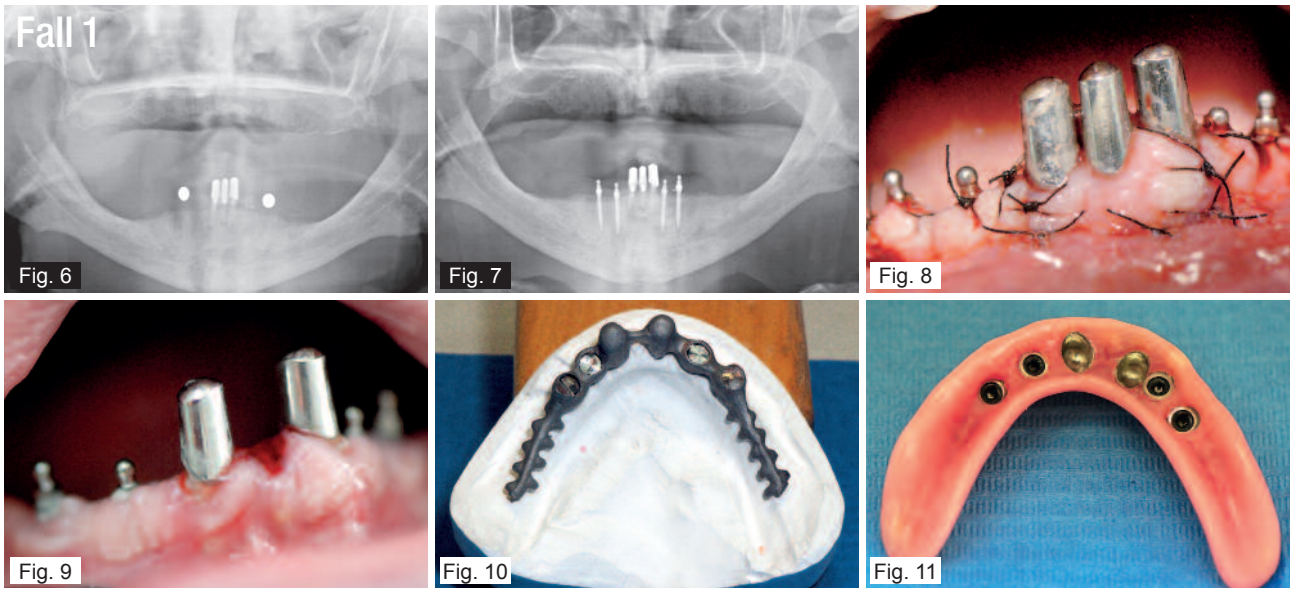

Fig. 6: Ball measurement recording for planning the implant positions and lengths. – Fig. 7: Collared implants, 2.1 mm in diameter and 13 mm in length, were placed. – Fig. 8: Clinical situation after implant placement. – Fig. 9: Situation after suture removal and extraction of tooth 31. – Fig. 10: Metal framework to reinforce the prosthesis base. – Fig. 11: Denture base with matrices for fixation on the mini-implants.

in the bone have been examined with the mentioned FE models. The important application of prostheses or partial dentures and bridges, which are supported by implants and residual dentition, could not be modelled and analysed so far. There is still a broad field of future research that will provide important insights for clinical application.

Strategic implant positioning

If the implants are used for anchoring partial dentures, careful planning of the strategic implant positions, taking into account the position and number of the remaining natural teeth, is crucial. So far, there have been no guidelines that dentists can use in the planning phase. Experts from the University of Greifswald, together with experienced resident dentists and employees of the company 3M ESPE (list Tab. 1), developed a planning scheme for the positioning of mini dental implants

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Tab. 1: Members of the working group who developed the planning scheme for the positioning of mini-implants to stabilize partial dentures.

serves, among other things, as the basis for a prospective study. The basis for deriving the guidelines was formed by existing systems for classifying gap dentition13,14 and by the recommendations of the implantology societies with regard to the number of strategic pillars (lower jaw: four pillars, upper jaw: six pillars) for removable dentures.

The new classification provides for a subdivision into six classes for the upper and lower jaws and considers one quadrant for each. The number of recommended strategic and optional implants differs according to the recommendations of the implantology societies depending on the jaw.

As with other classification systems, this classification assumes that the prosthetic value of the teeth differs depending on the position: an incisor contributes the least to the stability of the prosthesis, a tooth from position 4 already has a higher value and the strategically most important pillar is the canine. As soon as the canine is in place, only optional mini-implants need to be placed (classes 4 and 5, depending on the availability of a tooth from position 4). Classes 2 and 3 describe situations in which one or more teeth are present from position 4 - here one or two mini-implants are recommended in the upper jaw and one in the lower jaw. If, on the other hand, only incisors are present (class 1), three strategic implants must be inserted in the upper jaw and two in the lower jaw, as in the case of an edentulous quadrant (class 0).

The procedure for planning, implant placement and prosthetic restoration is described in detail using the following case studies.

Patient case 1

In a 77-year-old marcumarized patient, the retention of the lower jaw partial denture was unsatisfactory after the loss of teeth 43 and 45. Only three telescopic pillars remained (32, 31 and 41). With clinically stable and symptom-free teeth 32 and 41, the patient wanted an implant-based prosthesis that would provide the desired retention even in the event of further tooth loss, without having to add further implants. The jaw ridge width was clinically significantly reduced, but the patient refused augmentation measures. The classification for pillar augmentation with mini-implants resulted in a class 1 in both quadrants, in which two strategic implants are to be inserted. The implant length and positioning were planned using a ball measurement (Fig. 6). Two mini dental implants (3M ESPE) with a diameter of 2.1 mm and a length of 13 mm were inserted on both sides. The mucosal thickness of over 2.5 mm specified collared implants (Fig. 7 and 8). Tooth 31 was removed as part of the new restoration. Positioning and selection of the implants allow for a later extension of the prosthesis after possible extractions without the need to insert mini-implants again (Fig. 9-11). In this case, the prosthetic fitting was carried out in the dental practice of Dr. Thomas Wehse, Roland Wehse & Dr. Ute Trost in Prüm.

Patient case 2

IAfter the extraction of telescopic abutment 43 and loosened tooth 33, the 67-year-old patient complained about the lack of support of his partial denture (Fig. 12). After a detailed discussion of the different treatment alternatives, he decided that he wanted to keep his existing prosthesis, a pillar augmentation through implants and the incorporation of ball anchor abutments into the prosthesis. The cast model base of the prosthesis made this therapy option possible (Fig. 13). After evaluating the panoramic image (Fig. 14), palpation of the jaw ridge revealed a narrow jaw ridge with a jaw height sufficient for implants. Therefore, it was decided to carry out an additional three-dimensional radiological examination for the exact diagnosis of the available bone volume.
This study confirmed the following assumption: a narrow, high alveolar process was found in the lower jaw front (Fig. 15) and a good amount of bone in region 34 (Fig. 16).

Since an implant with a standard diameter could only be inserted in region 43 in conjunction with extensive augmentation and the patient refused this measure, the decision was made in favour of the insertion of mini-implants. The number of implants was discussed with the patient using

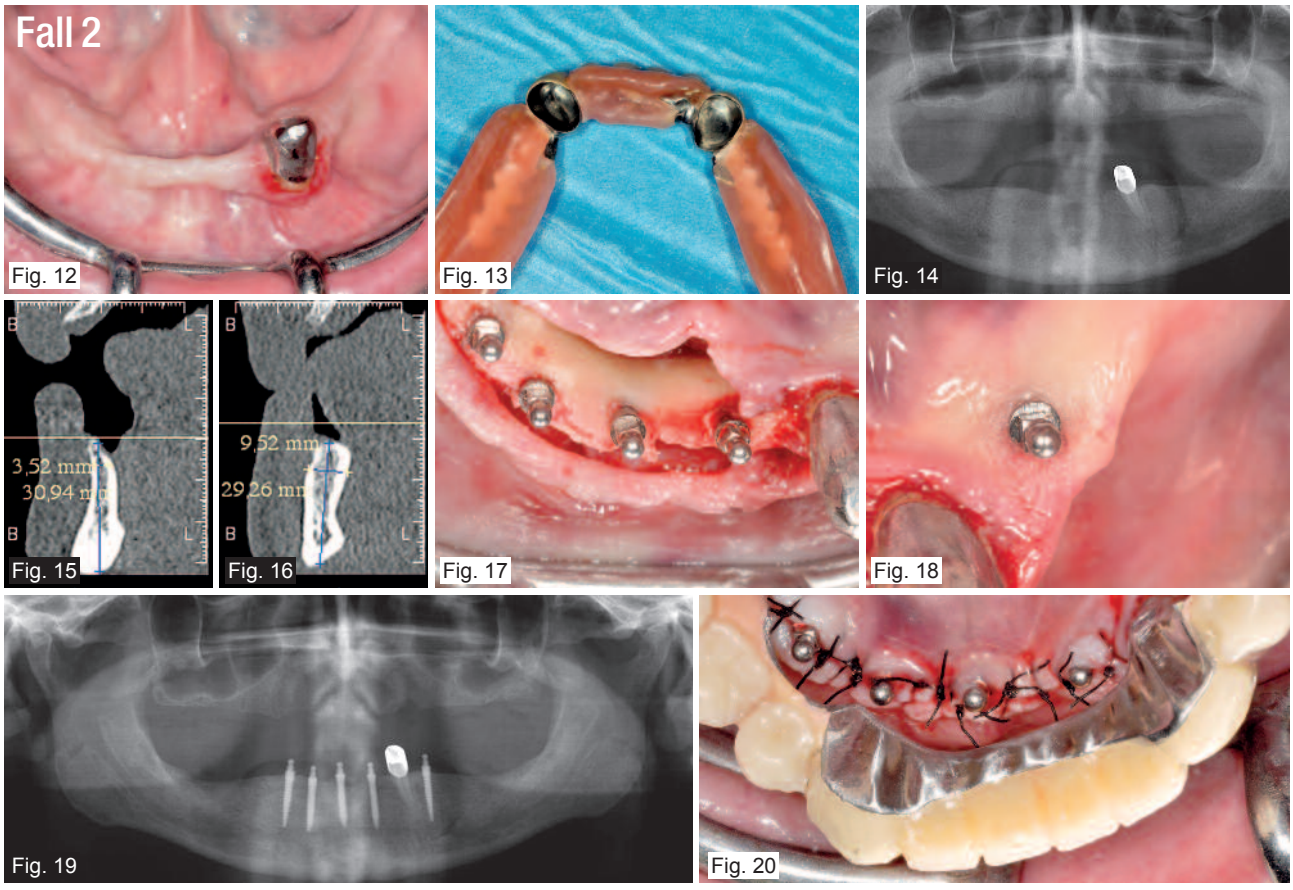

Fig. 12: Initial clinical situation. –Fig. 13: Existing prosthesis with model cast base. –Fig. 14: Panoramic image before implant placement. – Fig. 15: Lower jaw front: a high, narrow alveolar process can be seen. – Fig. 16: The bone available in region 34 is suitable for transgingival insertion. – Fig. 17: Inserted implants with a collar in region from 44 to 32. – Fig. 18: Transgingivally inserted implant in region 34. – Fig. 19: Postoperative X-ray. – Fig. 20: The existing prosthesis was ground free in the area of the implants and integrated postoperatively.

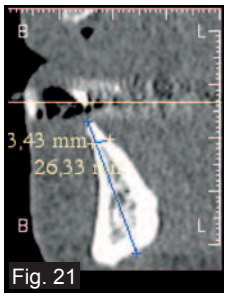

Fig. 21


Fig. 22

Fig. 23

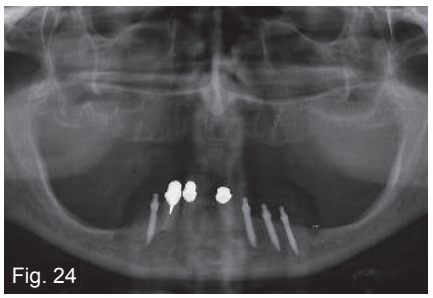
Fig. 24


Fig. 25

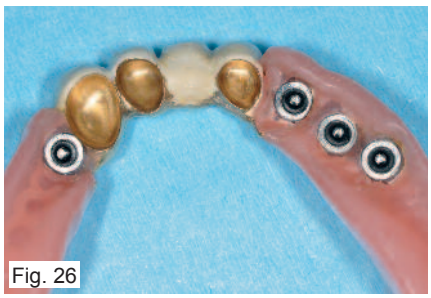
Fig. 26

Fig. 21: The analysis shows that the available bone is suitable for the insertion of mini-implants. – Fig. 22: Original, metal-reinforced prosthesis with a bridge element in region 41. – Fig. 23: Situation after insertion of the four mini-implants in the lower jaw. – Fig. 24: OPG control after implantation. – Fig. 25: Clinical situation after suture removal. – Fig. 26: Completed prosthesis from basal.

the above-mentioned planning scheme for the placement of strategic and optional implants. In the 3rd quadrant there was a class 4. Because the canine showed only minor loosening from overuse and a good prognosis, no strategic implants were required. However, the telescope offered only a small retention and renewal was not desired. In addition, the bone supply in region 34 was extremely good and in the front/canine region of the 4th quadrant an opening of the soft tissue for the insertion of implants was necessary anyway, due to the low bone availability. This incision could be extended to insert an implant in region 32. Therefore, optional mini-implants were planned in regions 32 and 34.

In the edentulous 4th quadrant, the situation corresponded to class 0 of the planning scheme. In addition to the two strategic implants in region 44 and 43, the patient also opted for an optional implant in region 42 for the above-mentioned reasons of optimal retention and the soft tissue opening that was necessary anyway. The available bone allowed the insertion of implants with a diameter of 2.1 mm and a length of 15 mm at all planned insertion sites; collared implants were selected due to the mucosal thickness of 2.5 mm. As planned, the implants were placed in regions 44, 43, 42 and 32 with the smallest possible opening and without a relief incision (Fig. 17) and implant 34 was placed transgingivally (Fig. 18). The positioning of the implants was checked using a final panoramic image (Fig. 19). In accordance with the manufacturer's recommendation, no immediate loading was carried out with this pillar increase. The design and stability of the existing model cast base made it possible to grind the prosthesis free in the area of the implants (Fig. 20). After a healing period of three months, the metal housing with O-rings could be inserted into the denture and the restoration could be completed, to the patient's satisfaction.

Patient case 3

The 72-year-old patient had been wearing a telescopic prosthesis anchored to teeth 31, 42 and 43 for many years. In the meantime, the canine had been endodontically treated and the root had been resected. The retention of the prosthesis was unsatisfactory and in the past year, the short post structure had loosened several times. An attempt had been made to insert a longer root pin. However, this was not possible due to the previously used hard root filling material, and forced drilling to remove the root post was avoided due to the risk of complications after previous root resection and at the request of the patient. The patient wished to keep the restoration and was informed about the possibilities of implantological pillar augmentation.

A three-dimensional diagnosis revealed a narrow bone profile that was suitable for mini-implants (Fig. 21). The patient refrained from additional augmentations.

The prosthesis design had a bridge element in region 41, so it was not possible to incorporate a matrix at this point (Fig. 22). The planning scheme resulted in a class 1 for the 3rd quadrant, for which the insertion of two strategic implants is planned. In the 4th quadrant there was a class 4 and thus the indication for an optional implant. Taking into account the special clinical situation with the short root pin and the loosening of the telescopic crown on tooth 43, as well as the associated questionable prognosis of the already root-resected tooth, the decision was made to insert an additional optional implant in region 32. This because an implant in region 41 and the subsequent incorporation of an attachment while preserving the existing prosthesis were not possible. Thus, four implants were planned in the lower jaw, as would

have been necessary with a prognostic loss of 43, albeit in an asymmetrical but acceptable distribution (Fig. 23-25). The modification of the prosthesis (Fig. 26) and the prosthetic fitting of the patient were carried out in the dental practice of Alexander Kosina and Dr. Nadezda Kosinova in Finnentrop.

Conclusion

Mini-implants are suitable for stabilizing partial and full dentures, particularly in patients with a narrow jaw ridge but good bone quality who decide against augmentative measures. The low treatment costs and the short period of time from the implant insertion to the final restoration are further advantages for the patient. As the three patient cases presented show, the MDI planning scheme provides dentists with a helpful instrument for classifying the gap dentition and for planning the positions in which mini-implants are to be inserted. Strategic and optional implants are clearly displayed. It is important, however, that the dentist personally always decides on the specific distribution and number of mini-implants - especially the optional MDI - for the individual case. Of course, clinical aspects such as the prognosis for the remaining dentition and limitations caused by an existing prosthetic fitting must be taken into account. In this way, it is possible to significantly improve the retention of prostheses and to offer patients a long-term prosthetic solution.

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