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Immediate implant supported prosthodontic treatment of the edentulous jaw with additional implant stabilization

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SUMMARY

Aim. To increase the reliability, quality, and incidence of favorable outcomes during mandibular direct implant prosthetic treatment using the Trefoil system.

Materials and methods. This study included 48 patients (age: 63–85 years). Visualization assessment (CBCT) was performed using Planmeca Promax 3D Mid, and bone density was examined using dual energy X-ray absorptiometry (densitometry, DXA). The final sample consisted of 16 patients deemed suitable for immediate implant placement and loading of permanent prosthesis on the mandible. The distal implants were stabilized using a customized structure made of Titanium Ti6-Al4-V using DMLM 3D printing technology with Concept Laser machines. Modeling of the contours of the jawbone at the planned surgical site was carried out using cone-beam computed tomography and the Mimics Medical 21 software (Materialize, Germany) for each patient. A total of 32 such devices were created.

Results. Of these, 18 were used as the initial implant stability was less than 35 N/cm of torque in a few cases only. The implant survival rate was 100% after 18 months. This method of mandibular implant prosthetic treatment using a customized device for implant stabilization has been patented.

Conclusion. Splinting of the compact walls of the mandible using a customized structure optimized stabilization of the Trefoil prosthetic construction on porous bone (type IV) following extraction of teeth and placement of implants. Clinical testing of the reported method confirmed its viability for dental rehabilitation of elderly patients and proved its ability to provide a good quality of life by creating stable implant prostheses with high functionality.

Keywords: Trefoil, individualized titanium mesh, implant supported prosthetics, geriatric dentistry, stabilization of dental implant.

INTRODUCTION

Trefoil implant prosthetics, in addition to the obvious advantages, also exhibit some limitations, the most significant of which is the absence of bicortical fixation most commonly seen with traditional implants (1). This method uses unicortical contact instead (Fig. 1, 2) and, over a period of 2-4 months, a new compact layer of bone is formed on the surface. Minimization of the risk of implant prosthesis loss prior to bone formation is essential as the Trefoil system does not provide adequate stabilization during this period.

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Compromised stabilization may be observed in cases of simultaneous tooth extraction, inadequate preparation of the bone implant bed, presence of porous bone, and existence of a wide gap between the lingual and labial compact layers of the mandible, and this is affected by the density and volume of the bone tissue. This, in turn, may necessitate removal of the entire structure and re-operation, which is undesirable in elderly patients.

Over the past few years, advancement of computer modeling methods in the world of dentistry have led to the development and use of individual titanium meshes as frameworks during alveoloplasty. These meshes are designed using cone-beam computed tomography, individual high precision modeling in accordance with the real anatomy of the jaw, and volumetric printing using a three-

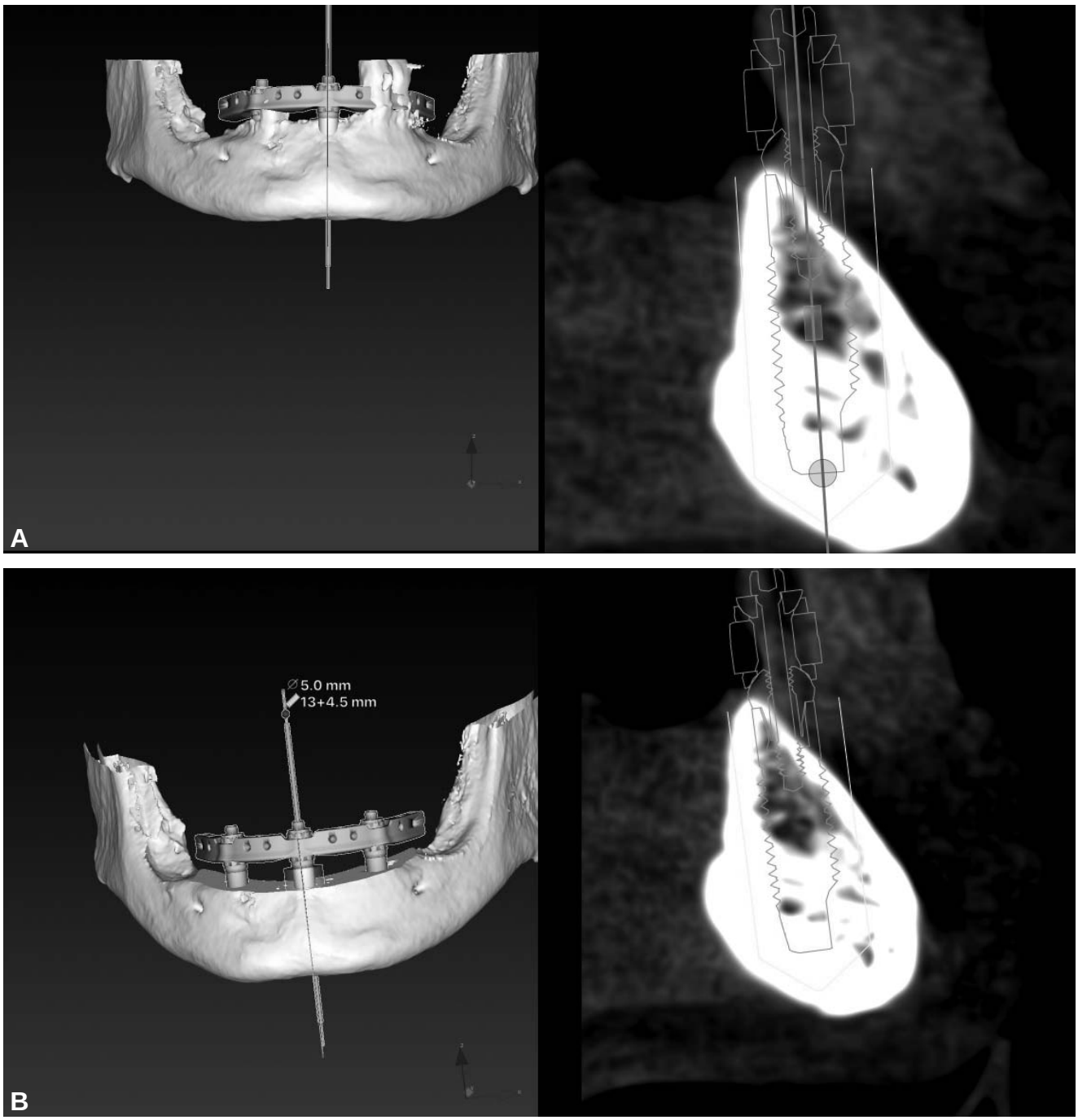

Fig. 1. Implant supported prosthodontic treatment plan using a Trefoil framework: A – matching the mandibular model with the framework without ridge reduction; B – matching the mandible with the framework after ridge reduction.

dimensional titanium printer, and help to minimize the risk of clinical complications (e.g., mesh cutting through the mucous membrane) by reducing the gap between the bone surface and titanium plate at points of fixation, regulate mesh size, and increase frame rigidity (2-4).

Therefore, our research goal was to increase the reliability, quality, and incidence of favorable outcomes when using the Trefoil system (consisting of three implants used in the absence of appropriate anatomical, topographic, and clinical conditions) for direct implant prosthetic treatment of edentulous mandibles. The result was provided by effective stabilization of the implant with insufficient mechanical fixation in the bone during the operation and the imposition of the implant prosthesis. To achieve this goal, our team developed and tested a method of mandibular implant prosthetic treatment that used a customized device to minimize the loss of stability of implants.

MATERIALS AND METHODS

Clinical and para-clinical examination of 48

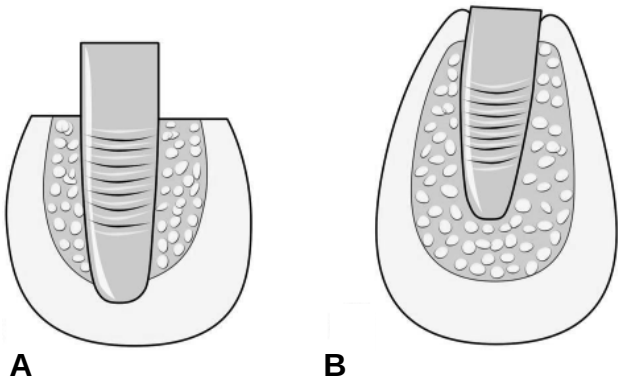

Fig. 2. Variations in mandibular implant insertion: A – unicortical; B – bicortical.

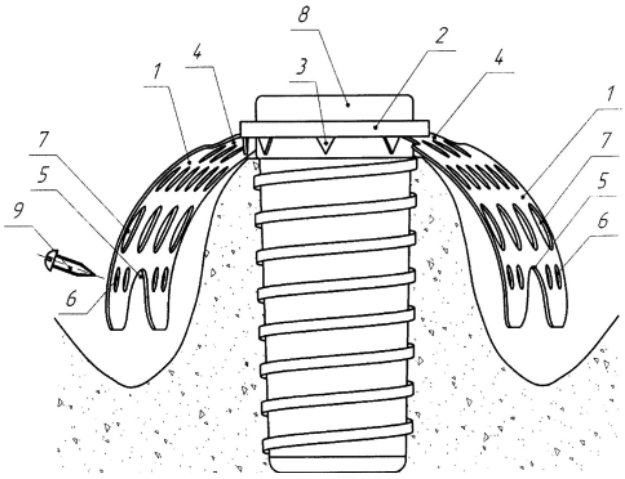

Fig. 3. Schematic representation of placement of the structure above the mandibular implant to increase stability of the dental fixture: 1) titanium plates; 2) connecting ring; 3) prongs for engaging into the cancellous bone; 4) narrowed parts of the titanium plates; 5) releasing cutaways of the plates; 6) opening for screw fixation; 7) complication prevention holes; 8) implant; 9) fixation screw.

patients (aged 63 to 85 years) who were referred to the orthopedic department of St. Petersburg State Dental Clinic, No. 33, between 2017 and 2019 for mandibular implant prosthetic treatment was carried out. X-ray examination (CBTC) was performed using Planmeca Promax 3D Mid (Finland) with Romexis ver. 4.5.1, and all patients underwent dual energy X-ray densitometry (DXA) to assess overall bone mineral density. Based on the radiological findings, 16 patients were deemed suitable for immediate treatment using three implants (diameter: 5.0 mm) as they exhibited an area of the mandible exceeding 9 mm in width with simultaneous occurrence of osteoporosis. Preoperative virtual surgical planning was performed using the Nobel Clinic program, and the use of a reinforcing frame was indicated if the level of stabilization was less than 35 N/cm. Modeling of the contours of the jawbone at the planned surgical site was carried out using cone-beam computed tomography and the Mimics Medical 21 software (Materialize, Germany) for each patient. A Concept Laser device (GE, Germany) was used to three-dimensionally print individual stabilization-enhancing devices made of titanium, which is known to have a high degree of rigidity Ti6-Al4-V (Materialize, Germany; analogue of the domestic VT6), for distal implants. A total of 32 devices were created, of which 18 were used in this study. The reinforcing frame was shaped like a cuirass, consisting of two perforated curved plates up to 1 mm in thickness and connected to each other by a ring (2). The ring had an inner diameter of up to 5.35 mm, which allowed it to be freely superimposed on the neck of the implant while leaving a gap with the neck surface. The ring had a square section measuring 1.5×1.5 mm and the entire perimeter of the lower part was supplemented using small triangular stopper-blades (3) for penetration into cancellous bone (Fig. 3).

The wing-shaped plates (1) were designed to be curly, with the narrower part (4) at the junction of the ring (2). The main part of the figured plate had a rectangular shape and a round cutout (5) on the side opposite to the ring to relieve stresses produced by bone elasticity and adaptation during device strengthening. All edges and transitions of the plates were rounded smoothly and the connecting ring was polished. The plate had a mesh-like appearance due to the presence of small round perforations for fixing screws (6) and larger perforations for the prevention of complications associated with possible deterioration in the blood supply to the mucous membrane. (7) The perforations covered approximately 50% of the surface area of the plate.

To ensure high accuracy during application, an auxiliary device consisting of an individual reduction template was designed using a polymer that can withstand thermal sterilization. The fixtures, sent in advance by the manufacturer, were then autoclaved (Fig. 4-6).

The surgical protocol for implant prosthetic treatment has been reported by us previously (1). However, alveolar reduction was carried out differently using the individual reduction template to allow effective use of the reinforcing device. Immediately after implantation, the connecting ring (2) of the device was applied to the neck of the implant and the thorns (3) were inserted into the cancellous bone by gently tapping the ring. The device was then fixed on the vestibular and lingual aspects using two titanium screws inserted through the holes.

Thereafter, the final implant prosthetic construction was fixed. The stability of the structure was

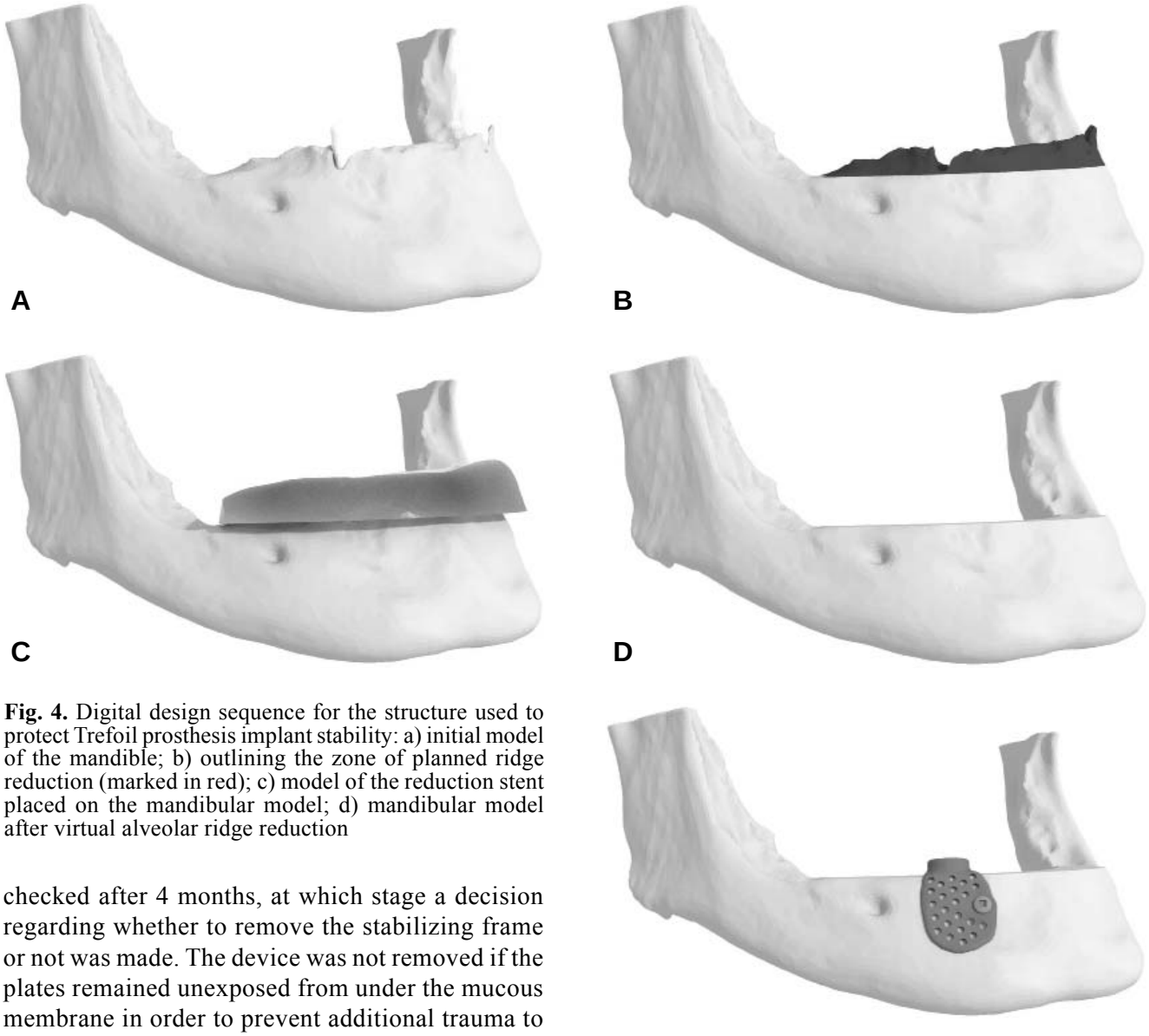

Fig. 4. Digital design sequence for the structure used to protect Trefoil prosthesis implant stability: a) initial model of the mandible; b) outlining the zone of planned ridge reduction (marked in red); c) model of the reduction stent placed on the mandibular model; d) mandibular model after virtual alveolar ridge reduction

checked after 4 months, at which stage a decision regarding whether to remove the stabilizing frame or not was made. The device was not removed if the plates remained unexposed from under the mucous membrane in order to prevent additional trauma to the elderly patient.

Figure 7 demonstrates fixation of the splinting device and auxiliary template to the area of implantation in the edentulous mandible of elderly patients.

RESULTS

The device described above was clinically tested in 16 patients (aged 63 to 85 years) who received ceramic-titanium full fixed implant prostheses using screw fixation and a standard Trefoil bar as the frame. A total of 18 out of 32 prepared devices were used as the primary stabilization values were less than 35 N/cm (after modification of the protocol to allow creation of an osteotomy channel), and the prostheses were evaluated 18 months after application. Utilization of the retention device was seen to produce 100% preservation of the implants, while absence of stabilization enhancement under similar conditions (pronounce porous bone) resulted in only 89% preservation.

To the best of our knowledge, this is the first Trefoil customized titanium mesh stabilization device to be used for implants.

This method of mandibular implant prosthetic treatment using a customized device for implant stabilization has been patented (RF Patent for invention No. 2720667, dated 05/12/2020; RF patent for utility model No. 196881, dated 03/18/2020) (8, 9).

DISCUSSION

L. Bai (2019) previously carried out a detailed mathematical analysis of the effect of mesh size and thickness on the mechanical properties of individually tailored titanium meshes used in alveoloplasty and found that the former had a lesser effect than the latter. A mesh thickness of 0.4 mm was found to be sufficient to prevent the mesh from penetrating

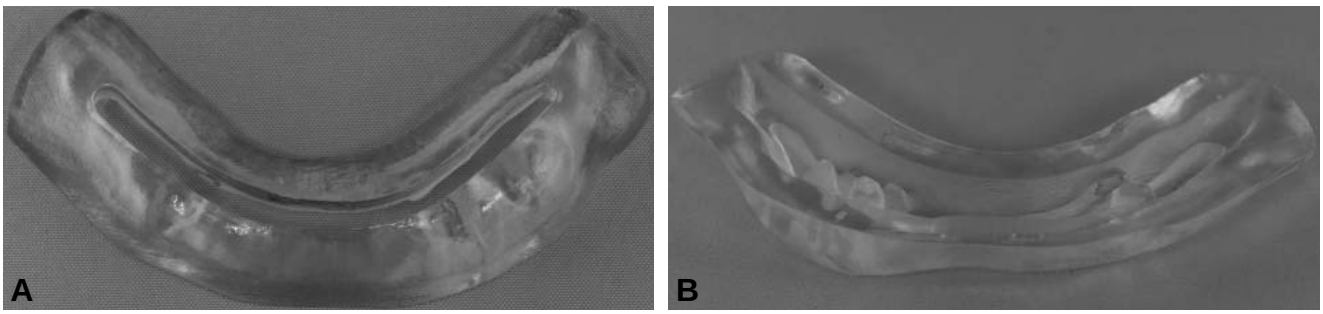

Fig. 5. 3D printed reduction stent made of resin: A – external view; B – internal view.

Fig. 6. 3D printed device used to protect Trefoil prosthesis implant stability, created using Titanium powder (DMLM technology)

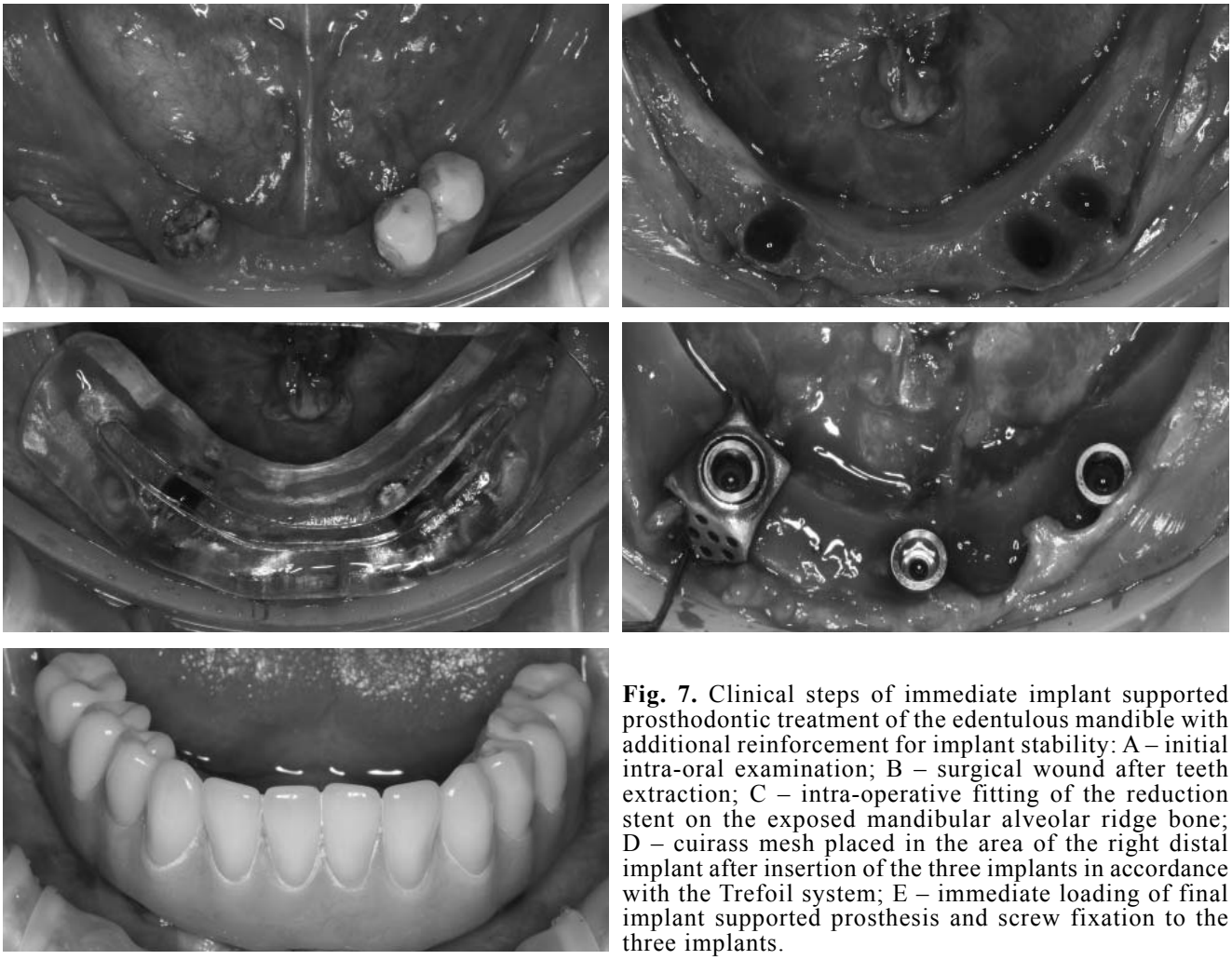

Fig. 7. Clinical steps of immediate implant supported prosthodontic treatment of the edentulous mandible with additional reinforcement for implant stability: A – initial intra-oral examination; B – surgical wound after teeth extraction; C – intra-operative fitting of the reduction stent on the exposed mandibular alveolar ridge bone; D – cuirass mesh placed in the area of the right distal implant after insertion of the three implants in accordance with the Trefoil system; E – immediate loading of final implant supported prosthesis and screw fixation to the three implants.

through the mucous membrane. The thickness of the individual stabilizing device is higher, and reaches 1.5 mm in the area of the ring, which is justified by the task of splinting between the inner and outer compact layers of the bone of the mandible body, which is loaded from the immediate prosthesis through the newly inserted implant. None of the mesh devices used in the current study were removed because of mucous membrane perforation.

The 3D laser-printing devices used in this study exhibited high precision, resulting in devices that could be superimposed without need for balance or adaptation to the bed. The accuracy of fit is highly dependent on the accuracy of the digital devices in the X-ray machine used for CBCT and the three-dimensional printer used for creation of the device by DMLM (direct metal laser melting) technology. Moreover, the novelty of the software used also plays a significant role. High precision levels have allowed clinicians to return to the idea of sub-periosteal implants, with C. Mongano (2020) reporting superior clinical results with sub-periosteal implants individually created by DMLS (direct metal laser sintering) technology for use in the distal parts of severely atrophied mandibles in elderly patients (6). Advancements in 3D printer technology allows higher levels of precision and extended titanium structures, and a practical study conducted by A. Tarsitano (2018) reported an accuracy of within 1 mm when 3D printing mandibular fragments in 34 patients (7).

CONCLUSION

Therefore, the device described above allowed splinting of the compact walls of the jaw, thus optimizing immediate stabilization of the Trefoil prosthetic construction on porous bone (type IV) following extraction of teeth and placement of implants.

Clinical testing of the reported method confirmed its viability for dental rehabilitation of elderly patients and proved its ability to provide a good quality of life by creating stable implant prostheses with high functionality.

CONFLICT OF INTEREST

The author declares no conflict of interest

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