Treating an edentulous mandible with an implant-supported prosthesis with a shape-memory alloy abutment system

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CLINICAL REPORT

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ABSTRACT

This clinical report describes a treatment protocol for completely edentulous patients using digital implant planning for an all-on-4 treatment of both the maxilla and mandible as well as the use of a shape-memory alloy retention system to secure a complete-arch restoration to the mandible.

INTRODUCTION

Screw-retained, fixed complete-arch prostheses are popular treatment options for edentulous patients due to their better implant survival rates\(^1\) and excellent patient satisfaction. Screw retention, however, has been associated with high rates of mechanical failure for reasons that include cantilever designs that act as force magnifiers\(^2,3\) and the presence of screw access channels, which compromise the structural integrity of the ceramic.\(^4\) Screwless fixed restoration systems have been developed recently to simplify this process, saving time and improving the esthetic outcomes. One approach uses a shape-memory nitinol alloy sleeve (Smileloc; RODO Medical) with 2 sets of engaging arms to mechanically interlock the prosthesis to the implant abutments. These engaging arms reversibly switch between a locked and unlocked state because of a phase transformation in the nitinol from the martensite phase at body temperature to the austenite phase at elevated temperatures (Fig. 1). The restoration is strongly retained during
normal use while still being easily removed following a short pulse of heat from an induction removal device (Smilekey; RODO Medical).

A treatment protocol for a completely edentulous patient is described. Digital implant planning for an all-on-4 treatment of both the maxilla and mandible was performed with the shape-memory alloy abutment components in the digital library. A shape-memory alloy abutment system was used to secure a complete-arch restoration to the mandible, and screw retention was used for the maxillary complete-arch restoration.

**CLINICAL REPORT**

A 75-year-old woman presented to the Branemark Osseointegration Centre (Hong Kong) with mobile maxillary and mandibular metal-ceramic fixed partial dentures. Her medical history revealed joint replacement surgery on the left hip and diabetes mellitus that was managed with medication. The patient was using a wheelchair. Her maxillary prosthesis was supported by 6 teeth and the mandibular prosthesis with 3 teeth. All abutment teeth were carious and periodontally involved (Fig. 2). Clinical examination determined all remaining teeth to be nonrestorable.

The accepted treatment plan included the extraction of all remaining teeth and immediate placement and loading of implants to support interim prostheses (Fig. 3). Implant treatment planning software (coDiagnostiX; Dental Wings GmbH) was used for digital preoperative implant planning (Fig. 4), and the double-scan cone beam computed tomography (CBCT) method was used for image acquisition. The first scan was of the patient wearing the interim prostheses with gutta percha markers and an occlusal index. The second scan was of the interim prostheses alone.
In the maxillary arch, an all-on-4 treatment procedure was planned which included a 45-degree tilt of the most distal implants and the use of angled multi-unit abutments (AMUAs). Specifically, the following implants (Nobel Biocare) were placed in the areas of the maxillary right first molar, right canine, left canine, and left first molar: BMK Speedy RP 4.0 × 25 mm with greater than 20 Ncm insertion torque and BMK Speedy RP 4.0 × 18 mm, BMK Speedy RP 4.0 × 20 mm, and BMK Speedy RP 4.0 × 20 mm, all with greater than 40 Ncm insertion torque. The sinus membrane above the left first molar was elevated with an open sinus lift procedure. Thirty-degree AMUAs were used for the posterior implants and 17-degree AMUAs for the anterior implants. The implant abutment screws were tightened to 15 Ncm. An interim screw-retained complete-arch prosthesis was delivered with immediate loading.

In the mandibular arch, an all-on-4 treatment procedure was also planned with implants placed perpendicular to the occlusal plane and the use of straight MUA (RODO Medical). The implants were placed in the areas of the mandibular right second molar (C.C Parallel RP 5.0 × 11.5 mm, greater than 20 Ncm insertion force; Nobel Biocare), right canine (C.C Parallel NP 3.75 × 18 mm, greater than 50 Ncm insertion force), left canine (C.C Parallel NP 3.75 × 18 mm, greater than 50 Ncm insertion force), and left second molar (C.C ParallelRP 5.0 × 11.5 mm, 20 Ncm insertion force). The posterior implant abutment screws were hand tightened, and the anterior screws were tightened to 35 Ncm. An interim complete-arch prosthesis retained by the shape-memory alloy retention system (Smileloc; RODO Medical) was delivered with immediate loading (Fig. 5).

After 3 months, definitive impressions of the implant positions were made using the open-tray technique. A cobalt-chromium bar and acrylic resin (DuraLay; Reliance Dental Manufacturing) was used to splint the impression copings at the abutment level while making the
impressions. Maxillary and mandibular resin framework patterns were prepared and digitized with a cast scanner (ZfxEvolution Plus; Zimmer Biomet) and software (ExoCAD; exocad GmbH) (Fig. 6). The scans were used to fabricate the titanium frameworks, which were sent to the laboratory for processing that included laser welding the precision copings (RODO Medical) for the mandibular fixed prosthesis. The maxillary fixed prosthesis was screw retained with 15 Ncm torque, and the mandibular fixed prosthesis was secured using the shape-memory alloy retention system (Smileloc; RODO Medical) (Fig. 7). The occlusion was assessed with a computerized analysis system (T-Scan Occlusal Analysis System; Tekscan). Radiographs confirmed the complete seating of the restorations (Fig. 8).

**DISCUSSION**

A shape-memory alloy abutment system has been previously used for posterior single-tooth restorations. The authors are unaware of a previous clinical report using this innovative retention system for a complete-arch fixed restoration. Appropriate abutment alignment and positioning is essential for the proper seating of complete-arch restorations using a shape-memory alloy abutment system. This was achieved partly with the use of digital implant planning software, which allowed the position of each implant to be verified before surgery.

A shape-memory alloy abutment system was not used for the maxillary complete-arch restoration because of the 45-degree tilt of the posterior implants in the maxilla. The RODO abutments were available with 0-, 17-, and 30-degree angulations at the time of the treatment. A 30-degree AMUA for screw retention was used for the posterior implants; however, proper alignment and seating of the complete-arch restoration with more than 1 tilted RODO abutment was not possible. It is possible to leverage a shape-memory alloy abutment system for maxillary
complete-arch restorations by using 3 RODO MUA with 1 screw; however, the decision was made to use screw retention for the maxillary complete-arch restoration of this patient. The future addition of abutments with 45-degree angle correction will address this limitation.

Screwless fixed restoration systems offer an efficient and straightforward approach to managing mechanical and/or biological complications that may arise after delivery and during the maintenance phase. Retrievability is often cited as the primary advantage of screw-based systems, but it is often only performed for screw loosening, fracture, peri-implantitis, or peri-implant mucositis because it is a time-consuming process. Beyond mechanical failures, clinical practice guidelines recommend removal only when patients fail to maintain adequate oral hygiene. In contrast, the shape-memory alloy sleeve rapidly unlocks with a short pulse of heat. Two methods are used to heat the shape-memory alloy sleeve: originally, an activation probe was inserted into lingual access holes in the crown, which allowed direct contact with the titanium coping, and 15 seconds of contact resistive heating was applied. Recently, an induction removal device (Smilekey; RODO Medical) was FDA-cleared to unlock the shape-memory alloy sleeve by using alternating magnetic fields to heat the nitinol sleeve above its phase transformation temperature within 5 seconds.

The long-term maintenance protocols for fixed complete-arch restorations using a shape-memory alloy abutment system will be different from conventional retention systems. Clinicians can easily inspect the soft tissue status and clean around implants by removing the prostheses in follow-up appointments. To seat the prostheses, clinicians only need to insert lockable Smilelocs and deliver the prostheses. The occlusion should remain unchanged since no drilling or restorative materials are involved. Also, fewer screw-access-hole-related complications and
mechanical failures are expected since there are no screw-access holes that can compromise the structural integrity of the substructure, teeth, and connection materials.

**SUMMARY**

An innovative shape-memory alloy abutment system was used in a mandibular fixed complete-arch restoration. Presurgical planning with the components in the digital library enabled a restoratively driven planning approach. The abutments retained the prosthesis with retention similar to that of a conventional screw-retained prosthesis, while the innovative induction removal device facilitated removal of the prosthesis for routine inspection and maintenance. The elimination of the screw-access hole allowed a repeatable occlusal scheme after each removal and insertion. Investigations are needed to evaluate the long-term success of complete-arch restorations retained by shape-memory alloy abutment systems.
REFERENCES


FIGURES

Figure 1. A, Shape-memory alloy retention system. B, Cross section illustration of mechanically interlocking mechanism used to retain dental prostheses to implant abutments. Shape-memory nitinol alloy sleeve has outer arms that engage coping undercuts and inner arms engage undercuts on abutment. Heating shape-memory alloy sleeves to 60°C causes instantaneous shape change that causes arms to disengage undercuts.

Figure 2. Patient presented with 2 maxillary fixed partial dentures supported by 6 teeth and mandibular fixed partial denture with 3 abutment teeth. All abutment teeth carious and periodontally involved. A, Frontal view. B, Panoramic radiograph.
Figure 3. A, Remaining teeth extracted. B, Interim removable complete dentures.

Figure 4. Presurgical maxillary and mandibular implant planning conducted from CBCT images acquired using dual scan protocol. CBCT, cone beam computed tomography.
Figure 5. A, Mandibular implants placed with RODO MU abutments and Smileloc sleeves. B, Interim prostheses retained by shape-memory alloy retention system (mandible) and screw retention (maxilla) delivered with immediate loading.

Figure 6. A, Definitive cast obtained after 3-months. B, Impression with framework pattern digitized. C, Titanium framework fabricated.
Figure 7. A, Definitive prostheses. B, Frontal view of prostheses in place. C, Maxillary complete arch prosthesis. Note presence of screw-access channels holes. D, Mandibular complete-arch prosthesis. Note absence of screw-access channels holes.
Figure 8. Postoperative panoramic radiograph.