**Table 1** Clinical Problem Outcome, Items of the Analysis

| | Categories of events/procedures |
|---|---|
| Walton and MacEntee,[1] 1993 | **Adjustments**<br>Any treatment that could be done without repairing or adding to the treatment<br>**Repairs**<br>Fixed: fracture of some component (screws)<br>Removable: loose or fractured retentive clips, relines<br>**Routine prevention** |
| Chaffee et al,[2] 2002 | **Scheduled/nonscheduled visits**<br>**No adjustments required**<br>**Adjustments required**<br>Denture adjustments, ball housing complications, prosthetic tooth complications, relines of mandibular and maxillary conventional dentures, abutment complications (tightening, replacement), miscellaneous complications |
| Attard and Zarb,[3] 2005 | **Maintenance procedures**<br>Conversion of prosthetic plan, damaged framework screws, damaged abutment screws, fractured framework (fixed prosthesis or Dolder bar), fractured denture teeth, fractured opposing denture, damaged clip mechanism, loose framework, laboratory reline of opposing denture only, laboratory reline of overdenture only, prosthesis adjustments, remake of implant prostheses, remake of new opposing denture |
| Stoker et al,[4] 2007 | **Specific aftercare treatment**<br>Overdenture—fracture, overdenture—remake, overdenture—rebasing<br>**Mesostructure**<br>Renew retention element, abutment fracture, screw fracture<br>**Assorted**<br>Renew tooth (prosthesis), remounting, occlusal repair |
| Visser et al,[5] 2009 | **Maintenance procedures**<br>Routine prevention and after-treatment inspection, oral hygiene instructions, removal of calculus, consult without treatment<br>Repair of denture teeth, repair of denture base, fabrication of new milled bar, replacement of Ceka attachment, fabrication of new denture, adjustment of occlusion level, reline of overdenture, repair of milled bar, grinding of occlusion, activation of Ceka attachment, relief of sore spots, replacement of screws/abutments, lengthening of denture base rim |

the results of studies. Clinical research should, therefore, analyze comparable entities of tissue-integrated prosthodontic constructions in order to detect the specific weaknesses of a given system. Furthermore, a common backbone taxonomy of relevant entities of clinical outcome and its costs is needed to overcome the case-by-case resolution of incompatibilities.

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# The Use of Computer-Aided Engineering in the Fabrication of Immediately Loaded Fixed Complete Dentures (All-on-Four Hybrid Prostheses)


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A unique prosthetically driven protocol has been developed that uses computer-aided engineering (CAE) to develop sophisticated, scientific algorithms that guide the fabrication of a conversion denture using established digital complete denture fabrication technology. The process begins by acquiring clinical records for fabrication of conventional AvaDent digital dentures (Global Dental Science; Fig 1). The data obtained from scans of these clinical records are used to fabricate provisional complete dentures along with

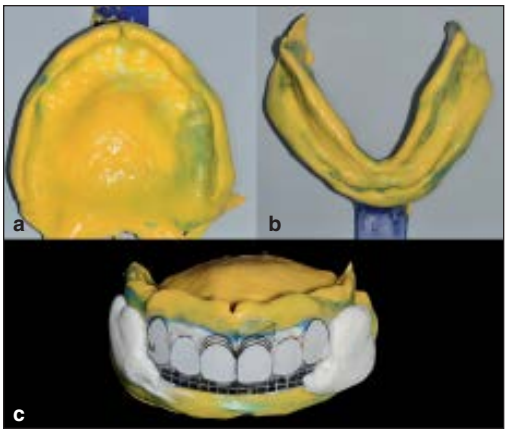


**Fig 1** **(a)** Maxillary and **(b)** mandibular complete denture impressions. **(c)** AvaDent anatomic measuring device used to record centric relation, occlusal vertical dimension, lip support, anterior tooth size, and anterior tooth positions.


**Fig 2** **(a, c)** Maxillary and mandibular provisional complete dentures. **(b)** Provisional complete dentures in patient's mouth. **(d)** Mandibular radiographic template.

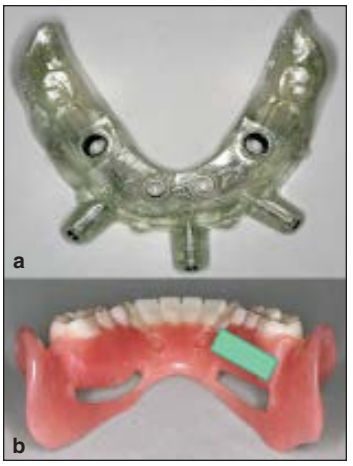



**Fig 3** *(left)* **(a)** NobelGuide surgical template. **(b)** Conversion denture with predrilled channels where the implants will be located and a peripheral slot with small struts of resin that connect the peripheral base to the central conversion denture.

**Fig 4** *(right)* **(a)** Conversion denture positioned over temporary abutments. **(b)** The occlusion with the maxillary provisional complete denture is used to orient the mandibular conversion denture so the resin used to connect the conversion denture to the temporary abutments polymerizes with the prosthesis in its proper relationship.

a radiographic template of the arch that will receive an implant fixed complete denture (hybrid prosthesis; Fig 2). The radiographic template is a digitally fabricated clone of the provisional denture for optimal dimensional accuracy. A cone beam computed tomography (CBCT) scan is made with the template in position and the resulting data imported into NobelClinician (Nobel Biocare) implant planning software so a NobelGuide surgical template can be fabricated for use in guided surgical implant placement. Because the surgical template identifies the position and angulation of the implants, it is used to identify the implant positions in a conversion denture. The conversion denture is made in advance of the surgery appointment with channels through the denture base where the implants will be located. It also is made with a peripheral slot that makes it easier to separate the peripheral base from the central conversion denture after the implants are placed (Fig 3).

At the time of surgery, the implants are placed using the NobelGuide surgical template, multi-unit abutments are attached to the implants, and then temporary abutments are attached to the multi-unit abutments. The conversion denture, with its predrilled channels, is seated over the temporary abutments with the occlusion from the opposing provisional prosthesis used to properly orient the conversion denture (Fig 4). Acrylic resin is flowed between the temporary abutments and the channels in the resin conversion denture to fix the provisional prosthesis in position. After resin polymerization, the denture is removed from the mouth and the peripheral base separated from the centrally located conversion denture to provide an immediately loaded provisional fixed prosthesis.

During the implant healing period, the previously obtained complete denture data are used to fabricate an AvaDent Implant Record Device (AIRD) using

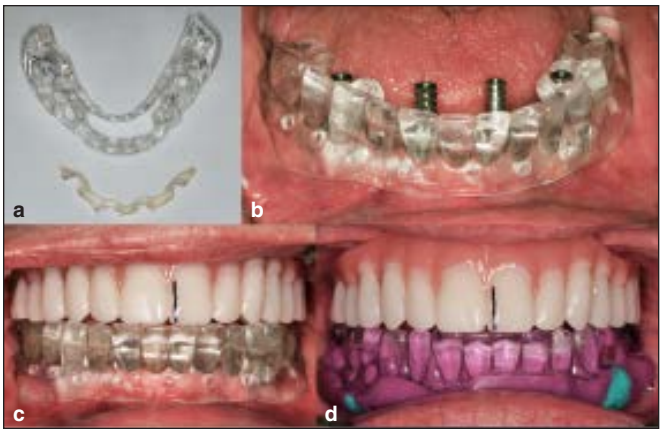


**Fig 5** **(a)** Mandibular implant record device (impression tray with teeth) with occlusal hole to accommodate prepolymerized verification jig shown at the bottom of the picture. **(b)** The verification jig is attached to temporary abutments using light-polymerized composite resin and the impression tray is seated over the jig. **(c)** The occlusion with the maxillary provisional denture is used to orient the impression tray to the proper occlusal position. The black line on the maxillary central incisor shows the midline so a slight correction can be made between the provisional and definitive maxillary complete denture. **(d)** Impression material is syringed around the verification jig, and the impression tray is seated with the occlusion, establishing the correct occlusal relationship between the implants and the maxillary denture occlusal surfaces.


**Fig 6** **(a)** The mandibular impression for the definitive prosthesis. **(b)** The interocclusal record made between the teeth on the mandibular impression tray and the maxillary denture teeth. Scanning of the interocclusal record will permit the occlusal relationship between the mandibular definitive fixed complete denture and the definitive maxillary complete denture. **(c)** The definitive mandibular fixed complete denture with integral milled titanium bar. **(d)** The definitive maxillary complete denture and mandibular prosthesis in centric occlusion.

computer-aided design/computer-assisted manufacture (CAD/CAM) milling. This device serves as a custom tray for making an impression for the definitive prosthesis. It is a digital clone of the previously fabricated conventional denture and, therefore, has teeth and a base like the denture. It also has an occlusal opening that accommodates a verification jig that will be attached to the implants.

At the definitive prosthesis impression appointment, the conversion denture is removed and temporary abutments are attached to the multi-unit abutments. The verification jig is attached to the temporary abutments and a passive fit of the temporary abutments to the multi-unit abutments is verified. The definitive impression is then made using the AIRD. The occlusion between the teeth on the AIRD and the opposing provisional denture guides the AIRD (impression tray) to its proper occlusal relationship (Fig 5). An interocclusal record is made between the AIRD and the opposing provisional denture. The impression records the position of the implants and their relationship to the prosthetic teeth in the AIRD while the interocclusal record relates the prosthetic teeth to the opposing denture teeth. Since the position of the implants and prosthetic teeth have been recorded by the AIRD, a scan of these records permits digital software planning to properly locate and design a CAD/CAM-milled titanium bar that will be embedded into a milled recess in the definitive fixed complete denture. The previously obtained digital data are used in conjunction with the interocclusal record to fabricate a definitive opposing prosthesis (Fig 6).

This new protocol makes it easier and more time efficient to convert a denture at the time of surgical implant placement and enhances the accuracy of the process and the resulting occlusal relationships due to use of the same digital data throughout the planning and conversion denture process. The definitive impression procedure is also enhanced in terms of time and accuracy by fabricating a custom impression tray with teeth that allows the implant positions and occlusal relationships to be simultaneously recorded.

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