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Immediate Occlusal Loading in Edentulous Jaws, CT-Guided Surgery and Fixed Provisional Prosthesis: A Maxillary Arch Clinical Report

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Abstract

Immediate occlusal loading (IOL) in edentulous jaws has been reported in numerous publications with implant cumulative survival rates consistent with conventional, unloaded healing protocols. Computed Tomography (CT)-guided surgery has more recently been developed and accepted as an additional treatment modality for maxillary and mandibular implant placement, with or without IOL. Reports as to the accuracy of planned versus actual implant placement in CT-guided surgeries have indicated that CT-guided surgery is not 100% accurate; standard deviations have been reported with values between 1 and 2 mm in terms of actual versus planned placement. The purpose of this article is to review the clinical parameters associated with IOL, and CT-guided surgery in edentulous jaws; and to present a clinical case illustrating the clinical and laboratory phases of treatment. The illustrated treatment was accomplished with an IOL protocol and includes fabrication and placement of a laboratory-processed provisional maxillary prosthesis. This particular protocol had slightly increased costs relative to conventional implant placement; however, the clinicians and patient benefited from improved accuracy of the provisional prostheses and decreased chairtime for the clinical procedures. The benefits and limitations of this treatment protocol are also discussed.

In the 1960s, loading dental implants with functional occlusal forces immediately after placement frequently resulted in fibrous encapsulation of implants, implant mobility, and loss of implants and prostheses.[1] Branemark et al[2] initially described the placement and restoration of endosseous, machined (turned) titanium implants with surgical and prosthetic protocols that included unloaded healing.[3] Over the past three decades, the use of dental implants continued to grow in clinical use and, under certain circumstances immediate occlusal loading (IOL) of endosseous implants was found to be as efficacious as the results of unloaded healing protocols previously reported.[4-11] Two of the primary treatment benefits of IOL protocols include reduction in the number of surgical procedures and in the amount of time required for insertion of immediate, fixed, provisional prostheses. To be successful in clinical practice, IOL protocols must provide similar implant survival rates when compared with the cumulative survival rates (CSRs) associated with unloaded healing protocols.

The purpose of this article is to review studies associated with IOL in edentulous mandibular and maxillary jaws; identify the benefits and limitations associated with computed tomography (CT)-guided surgery; and briefly illustrate the clinical and laboratory steps associated with fabrication of an immediate provisional maxillary prosthesis fabricated from digital data of a cone beam CT (CBCT) scan.

IOL, mandible

Schnitman et al reported the results of a clinical study with immediate fixed interim prostheses supported by machined implants in the treatment of mandibular edentulism.[4,5] They reported that the 10-year CSR for all implants in their study was 93.4%; the 10-year CSR for the immediately loaded implants was 84.7%; the 10-year CSR for the nonloaded implants was 100%. These two sets of data were statistically significant ($p = 0.022$).

Table 1 Published reports on immediate occlusal loading in edentulous jaws

Authors	Year published	Implant cumulative survival rate%	Length of time (years)	Implant manufacturers	Maxillary jaws/implants	Mandibular jaws/implants
Tarnow et al[6]	1997	98	1–5	4	4/33	6/41
Cooper et al[7]	2002	100	1.5	1	0/0	10/54
Horiuchi et al[8]	2000	97.2	2	1	5/44	12/32
Grunder[9]	2001	92.3	2	1	5/35	5/32
Testori et al[10]	2003	98.9	4	1	0/0	15/92
Testori et al[11]	2004	99.4	1–5	1	0/0	62/325

Numerous authors have reported the results of clinical studies with immediate loading of dental implants with similar results (Table 1). These reports concentrated mostly on patients with edentulous mandibles (CSRs 84.7% to 99.4%). The reported implant insertion torques ranged from 20 to 50 Ncm. Earlier researchers may have concentrated on implant treatment of edentulous mandibles because mandibular edentulism was viewed as a priority within the dental profession secondary to the amount of problems associated with mandibular complete dentures.

Considerations for maxillary dental implants

Loss of teeth, especially when combined with changes secondary to aging, tends to manifest clinically as facial changes and may include decreased lip support and decreased vertical facial height.[12] Tallgren reported that the mean resorption of the anterior height of edentulous mandibles during the first 6 months of denture use was approximately twice the mean maxillary resorption rate.[13,14] Resorption of the edentulous jaws continued, and at 7 years, Tallgren reported that mandibular bone loss was approximately four times greater than that observed in edentulous maxillae. Many patients who wear complete dentures experience considerable difficulty adapting to their prostheses;[15] however, patients have also reported that they tend to adapt better to maxillary versus mandibular complete dentures; this may be related to the fact that clinicians are generally able to make maxillary complete dentures more retentive and stable than mandibular complete dentures.[16]

Edentulous jaws undergo predictable patterns of resorption; however, the timeframe is not predictable. Lekholm and Zarb stated that it is essential for clinicians to consider the anatomic features of edentulous jaws in terms of jaw shape and jawbone quality when treatment planning dental implants.[17] Their classification system for jaw shape described the approximate shapes of edentulous ridges from Type A (minimal resorption, minimal loss of height and width) to Type E (extreme resorption with virtually no height and minimal width). The classification system for jawbone quality was described as Type 1 (almost the entire jaw comprises homogeneous compact bone) to Type 4 (a thin layer of cortical bone surrounds a core of low-density trabecular bone). Experienced clinicians know that severely resorbed maxillae present serious limitations for conventional implant placement and prosthetic rehabilitation in terms of bone quality and quantity: anterior maxillae resorb in superior and posterior directions; posterior maxillae resorb superiorly and medially; resorption and loss of bone volume is chronic and irreversible. Maxillary anterior ridges may resorb to such an extent that pressures can be exerted directly onto the anterior nasal spine, causing pain and increased maxillary denture movement during function.[18]

Dental implants, in addition to providing increased retention and support for prostheses, also provide an additional benefit in that dental implants maintain alveolar bone volume.[19] Endosseous implants are thought to maintain bone width and height as long as the implants remain anchored to bone with healthy, solid attachments.[20]

During the last two decades, surgical techniques have been developed to prepare resorbed maxillae for dental implants with varying results. The most common surgeries recommended for the treatment of maxillary edentulism with severe resorption for site preparation prior to implant placement have involved sinus floor elevations and reconstructive surgery with bone grafting.[21] Surgeries are invasive and result in increased morbidity secondary to the procedures.[22–24] If bone resorption can be minimized by placing dental implants closer to the time teeth are lost, the increased morbidity and costs associated with significant surgical grafting procedures would be minimized or eliminated.

IOL, maxilla

Edentulous maxillae are, in general, remarkably different from edentulous mandibles at macroscopic and microscopic levels. Especially when compared to the interforaminal portion of edentulous mandibles, maxillary bone is much more trabecular and, therefore, less dense.[25,26] It is therefore more difficult to achieve high levels of maxillary implant stability at implant placement (primary stability). Primary implant stability is considered to be one of the most important factors for successful osseointegration of dental implants.[26,27] In soft bone, undersizing osteotomies and selecting implants with differing shapes, lengths, and diameters may help to overcome some anatomic limitations and allow implants to be placed with high primary stability.[28,29] Insertion torque of at least 40 Ncm has been suggested as the minimum value acceptable for IOL,[29] although there is some debate on this subject as it pertains to multiple, splinted implants versus single, unsplinted implants.[30,31] Brunski suggested that micromovement of implants

Table 2 Published reports on immediate occlusal loading in edentulous maxillae

Authors	Year published	Implant cumulative survival rate%	Length of time (years)	Implant manufacturers	Maxillary jaws/implants
Testori et al[38]	2008	98.8	1–5	1	41/246
Ibañez et al[39]	2005	100	6+	1	26/128

within osteotomy sites may have a negative impact on osseointegration.[32] Consequently, carefully controlled surgical and prosthetic protocols must be followed to achieve predictable osseointegration.[33]

In the past several years, a number of reports have addressed the treatment of edentulous maxillae with implant-supported prostheses.[27,34-39] In a literature review of maxillary IOL, Del Fabbro et al[31] found a wide variety of approaches in terms of numbers of implants as well as surgical and prosthetic protocols. They reported the mean number of implants placed for maxillary immediate loading was 8.18. Additional reports are noted in Table 2. In another review concerning the outcomes of clinical studies on immediate and early loading, Attard and Zarb[37] identified shortcomings and suggested a number of questions that required exploration. Within the limitations of their review, Attard and Zarb concluded that treatment protocols involving IOL were predictable in the anterior mandible, irrespective of implant type, surface topography, and prosthesis design (survival rates 90% to 100%).

CT-guided surgery

Advances in CT technology have enabled surgical outcomes (clinical implant placement) to be predictably obtained with preoperative prosthetic treatment planning. Implant placement can be accomplished based on computerized, 3D plans instead of with 2D radiographs or as a result of a particular surgeon's experience, dexterity, and knowledge of the prosthetic treatment plan and the specific anatomic contours of a given patient. CBCT scans provide the advantages of conventional CT images with decreased radiation exposure, without superimposition or blurring, and axial/cross-sectional images of CT data.[40]

Preoperative treatment planning typically includes radiographs and ridge mapping; ridge mapping alone is insufficient to accurately predict the amount and shape of edentulous sites, particularly in anterior maxillae. It is well known that information on bone width is lacking in conventional radiography; radiographic bone heights may also be inadequate, secondary to distortion caused by positioning errors and variable magnifications.[41,42] Veyre-Goulet et al assessed and quantified the accuracy of linear measurements provided by CBCT using an image intensifier tube and television chain as an X-ray detector, on dry skulls.[43] They concluded that CBCT images provided reliable information on bone quality for preoperative implant planning in posterior maxillae. One of the limitations of this study was the lack of soft tissue on the dry skull specimens and potential positioning errors, and how that might have affected the data.

In approximately 2000, rapid prototype medical modeling and the use of stereolithographic (SLA) surgical guides manufactured from CT scans became available to the dental profession.[44-46] Compared to conventional radiography, CT-guided surgery requires substantial financial investment and effort (CT imaging, fabrication of scanning appliances, intraoperative referencing for bur tracking, and/or image-guided manufacturing of surgical templates); CT-guided surgery appears to be superior to non-CT-guided surgery due to its potential to eliminate possible manual implant placement errors and to systematize reproducible treatment success. However, according to Widmann and Bale, long-term clinical studies are necessary to confirm the value of this strategy and to justify the additional radiation dose, effort, and costs.[46]

Ozan et al reported the results of a clinical study that determined angular and linear deviations at implant restorative platforms and implant apices between CT treatment-planned and actually placed implants using SLA surgical guides.[47] The mean angular deviations of all placed implants from the planned placements are recorded in Table 3. Ozan et al concluded that SLA guides using CT data may be reliable in implant placement; tooth-supported SLA surgical guides were more accurate than bone- or mucosa-supported SLA surgical guides. Ersoy et al reported on the results of 92 implants and found that compared to where implants were planned, the placed implants showed angular deviations of $4.9 \pm 2.36^{\circ}$[48] (Table 4). In light of these findings, Ersoy et al also concluded that SLA surgical guides using CT data may be reliable in implant placement.[48]

It is important to note that the linear errors reported in the above studies were in the range of 1 to 2 mm. Surgeons should

Table 3 Comparison of planned implant locations versus actual implant locations (Ozan et al 2009)

Mean angular deviation (SD) Degrees	Mean linear deviation (SD) (restorative platform) mm	Mean linear deviation (SD) (implant apex) mm	Mean angular deviation (SD) tooth-supported degrees	Mean angular deviation (SD) bone-supported degrees	Mean angular deviation (SD) mucosa-supported degrees
4.1 (2.3)	1.11(0.7)	1.41 (0.9)	2.91 (1.3)	4.63 (2.6)	4.51 (2.1)

Table 4 Comparison of planned implant locations versus actual implant locations (Ersoy et al 2008)

	Mean angular deviation (SD) degrees	Mean linear deviation (SD) restorative platform (mm)	Mean linear deviation (SD) implant apex (mm)
All implants	4.9 (2.36)	1.22 (0.85)	1.51 (1.0)
Maxillary implants	5.31 (0.36)	1.04 (0.56)	1.57 (0.97)
Mandibular implants	4.44 (0.31)	1.42 (1.05)	1.44 (1.03)

probably not take the data provided by CT scans as their one and only guide for implant placement, as 1 or 2 mm may be quite significant in regard to the depth of a particular osteotomy near an inferior alveolar neurovascular bundle and canal.

Maxillary clinical (IOL protocol) and laboratory treatment with a fixed provisional prosthesis from CBCT data

A 55-year-old man, previously treated with mandibular implants, presented to the authors and requested an evaluation regarding maxillary implants. He had previously been treated with an IOL protocol in his edentulous mandible. The patient and clinicians were comfortable with the esthetics of the preexisting maxillary complete denture. The preliminary panoramic image indicated that the patient appeared to have adequate bone volume for maxillary implant placement (Fig 1). A scanning appliance was duplicated from the existing denture in a combination of clear autopolymerizing acrylic resin (Jet Acrylic, Lang Dental Manufacturing Co, Inc., Wheeling, IL) and barium sulfate (E-Z-HD Barium Sulfate For Suspension 98%W/W, E-Z-EM Canada, Inc., Westbury, NY) (Fig 2). The scanning appliance was placed into the patient's mouth, the patient was guided into centric occlusion, and a CBCT scan was taken. The data from the CBCT scan were reformatted (3D Diagnostix, Brighton, MA) and returned to the authors for evaluation and treatment planning. The patient was evaluated per the parameters of the American College of Prosthodontists (ACP) Prosthodontic Diagnostic Index (PDI).[49] Key physical findings were noted as follows:

(1) Adequate maxillary residual ridge (Class A).
(2) Class I skeletal jaw relationship.
(3) Maxilla did not require preprosthetic surgery.
(4) Adequate interocclusal space (18 to 20 mm).

The scan was evaluated as to the amount and location of bone available for maxillary implants relative to a fixed implant-retained prosthesis (Figs 3 and 4). This patient was classified as Class I per the ACP PDI.

Eight implants were treatment planned. The digital data were sent to a software manufacturer (Materialise Dental, Glen Burnie, MD); surgical, prosthetic, and laboratory treatment plans (Navigator System for CT-Guided Surgery, Biomet 3i, Palm Beach Gardens, FL), and an SLA surgical guide were received (Fig 5). These were sent to a commercial dental laboratory (North Shore Dental Laboratories, Lynn, MA) for fabrication of the master cast with implant analogs, articulator mounting, and construction of the fixed provisional prosthesis.

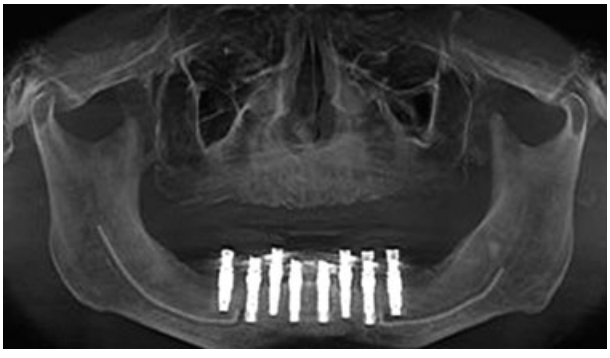

Figure 1 Panoramic computed tomography image of the patient illustrated in this report, 12 months postgrafting of the maxillary sinuses. There appeared to be adequate bone volume for maxillary implants. The mandibular implants had been placed and restored with an immediate loading protocol approximately 6 months previously.

Laboratory procedures

Implant analogs and implant analog mounts were selected consistent with the treatment plan (Fig 6). Analog mounts were oriented and connected to implant analogs with light finger pressure. Implant analog mount/implant analog complexes were placed into the guide tubes within the SLA surgical guide (Fig 7). Two notches in the analog mounts (180° apart) were seated into the corresponding areas in the tubes; thumb screws were hand tightened. Aligning the notches oriented the hexes of the implant analogs into the guide tubes; this hex timing was transferred to the hex orientations of the implants clinically.

Impression material (Aquasil LV, Dentsply Caulk, Milford, DE) was injected onto the intaglio surface of the surgical guide, occlusal to the implant analog/analog mount junctions to simulate the periimplant soft tissues. The surgical guide was boxed as if it was a definitive impression. Dental stone (Diamond Die, Hi-Tec, Greenback, TN) was mixed per the manufacturer's instructions, vacuum spatulated, and vibrated into the intaglio surface of the surgical guide. The stone was allowed to set, and the guide was removed. This cast was similar to a cast made from an implant-level impression (Fig 8).

A duplicate denture (scanning appliances may also be used) went to place on the maxillary cast; the cast was mounted

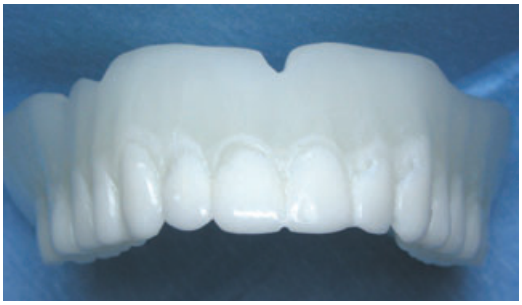

Figure 2 Scanning appliance made as a duplicate of the existing maxillary denture. Barium sulfate was added to autopolymerizing acrylic resin powder in the following ratios: 30% for the teeth, 10% for the denture flange. Monomer and resin were mixed and poured into the mold. Scanning appliance was finished and polished in conventional fashion. The patient had the scanning appliance in place during the cone beam computed tomography scan.

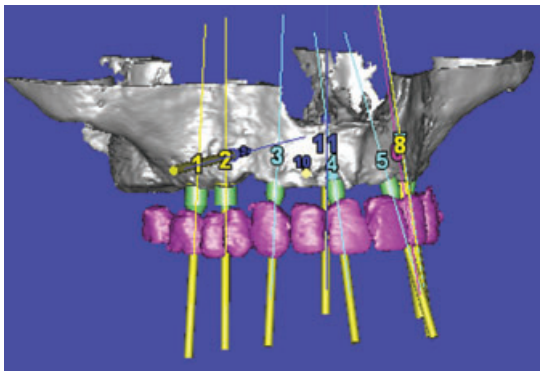

Figure 3 Reformatted computed tomography image of patient's maxilla with scanning appliance in place. Teeth and implant/abutment locations were designed to place each implant directly behind the corresponding tooth.

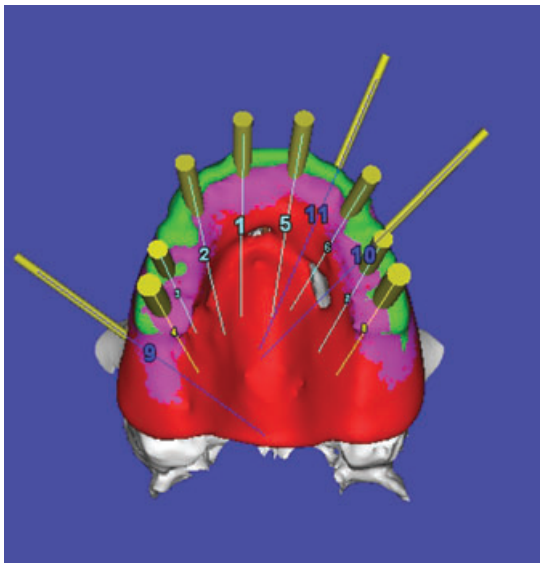

Figure 4 Reformatted computed tomography image demonstrated that the screw access openings exited the prosthesis palatal to the labial and buccal surfaces of the prosthesis.

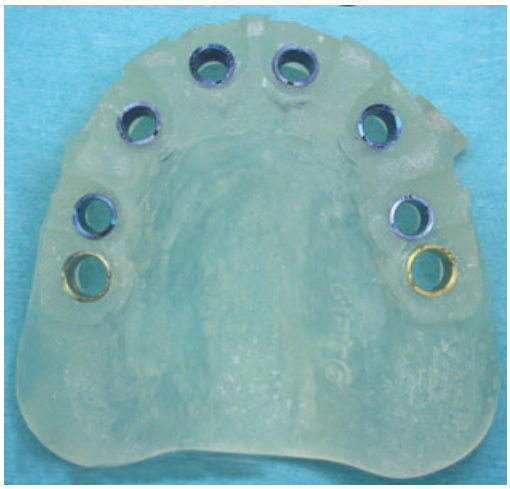

Figure 5 Occlusal surface of the stereolithographic surgical guide, as received from the manufacturer. Guide tubes were placed into the guide consistent with the locations and diameters of the implants in the treatment plan. The gold-colored guide tubes were designed for 5-mm diameter implants; the blue guide tubes for 4.1-mm diameter implants.

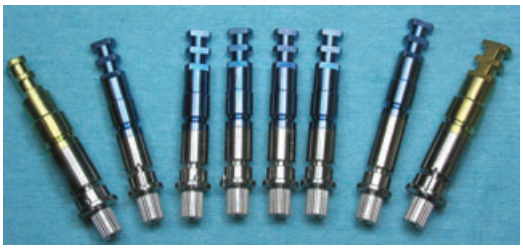

Figure 6 Analog mounts attached to implant lab analogs. Analog mounts reflect the amount of distance between the occlusal surface of the surgical guide and the crest of the alveolar bone (prolongation). Specific mounts were identified on the laboratory portion of the treatment plan for each implant site. Implant analogs were selected consistent with the implant diameters (patient's right to left) identified on the prosthetic portion of the computer-generated treatment plan.

Figure 7 The left image illustrates an analog mount not completely seated into the corresponding notches on the guide tube in the surgical guide. The center image illustrates implant analogs, attached to analog mounts placed accurately into the guide tubes in the surgical guide for this patient. The image on the right illustrates the notch in the analog mount completely seated into the corresponding area of the guide tube. The second notch is located 180° from the notch visualized above. Thumb screws were tightened by hand. Analogs cannot move in the surgical guide; timing of the hexes was transferred to the master cast and then to the clinical implants at the time of implant placement.

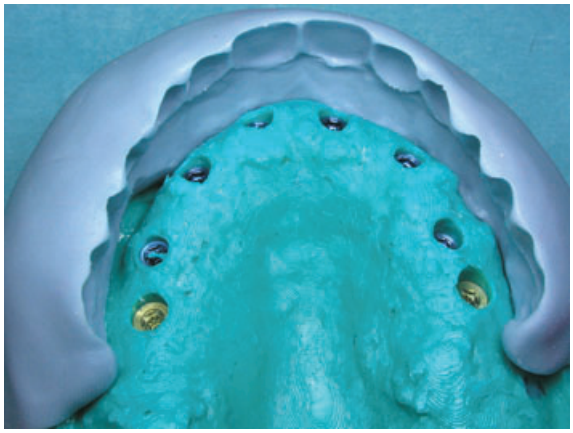

Figure 8 Silicone index, made from the wax denture, in place on the land area of the master cast.

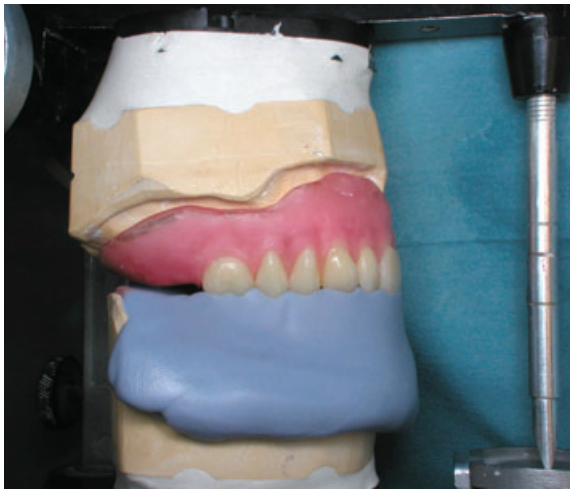

Figure 9 Maxillary wax denture seated on the master cast in the articulator; previously fabricated interocclusal record was used to mount the casts in the articulator.

Figure 10 Abutments were placed into appropriate implant analogs, consistent with the prosthetic treatment plan. The anterior six components were designed for screw retention; the two posterior components were designed for cement retention.

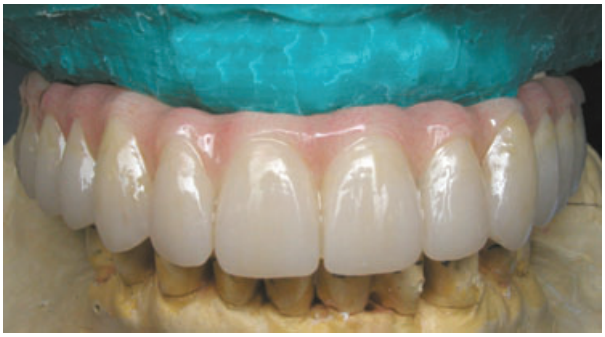

Figure 11 Definitive provisional prosthesis in place on the master cast. The prosthesis was fabricated with even occlusal contacts against the mandibular teeth. Gingival-shaded acrylic resin decreased the clinical crown heights in the provisional prosthesis. These contours were similar to the contours in the patient's existing maxillary denture.

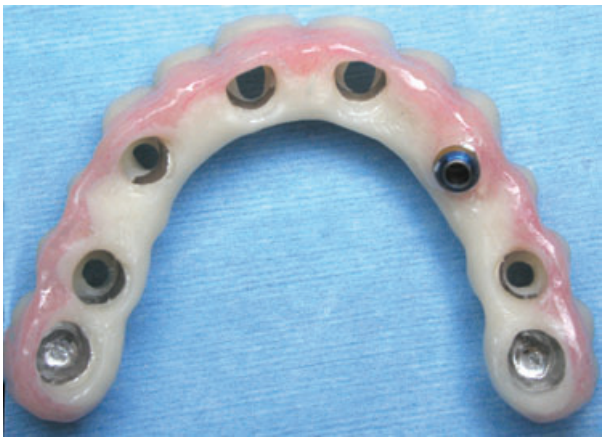

Figure 12 Intaglio surface of the provisional prosthesis. The cylinder on the patient's right side was processed directly into the prosthesis. The other components would be picked up clinically with acrylic resin.

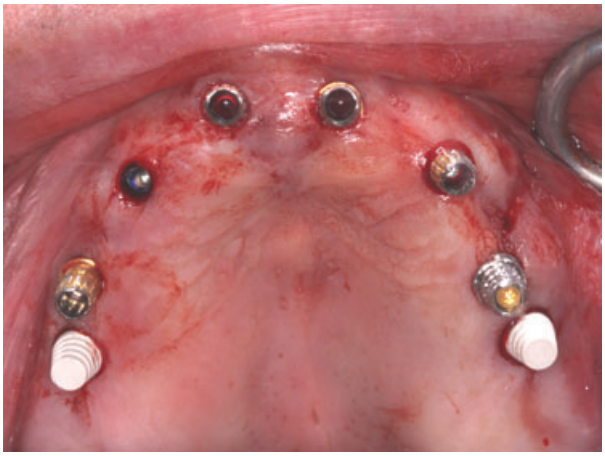

Figure 13 Prosthetic components, consistent with their positions in the master cast as determined in the virtual treatment plan, in place in the implants.

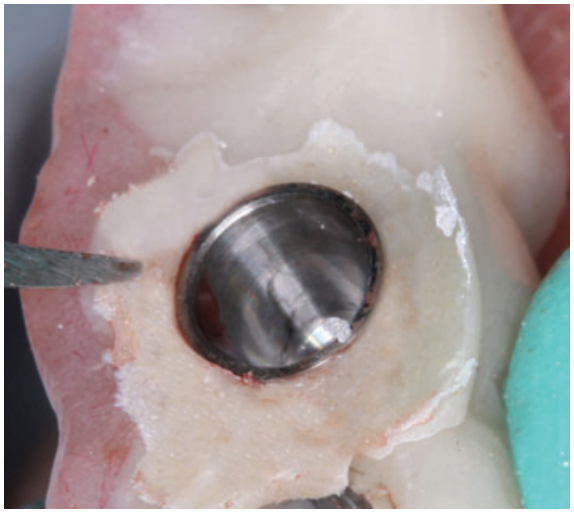

Figure 14 Intaglio surface of the prosthesis after the nonhexed abutment in the left maxillary cuspid site was picked up with acrylic resin intraorally. The flash was removed prior to the next step.

into the articulator with a laboratory-generated interocclusal record (Fig 9). Information from the original denture was now registered in the articulator mounting and would be used in constructing the provisional prosthesis.

The appropriate abutments were placed into their corresponding implant analogs (Fig 10). The maxillary prosthesis was waxed consistent with the arrangement of the denture teeth in the wax denture. The wax prosthesis was invested, boiled out, and processed with heat-cured acrylic resin. Due to the amount of vertical bone resorption, missing gingival tissues were replaced with gingival-colored acrylic resin in the provisional prosthesis (DVA C&B Resin Plus, Indenco Dental Products, Corona, CA). This decreased the relative lengths of the clinical crowns of the teeth in the provisional prosthesis and provided a natural, esthetic result (Fig 11).

Screw-retained implant prostheses (SRIP) present a unique advantage when compared to cement-retained prostheses: SRIP are retrievable.[50] This is especially critical when IOL is planned.[50,51] One of the major limitations associated with the use of acrylic resin is the distortion and dimensional changes that occur with polymerization.[52] To compensate for this, the authors decided to process one screw-retained cylinder into the provisional prosthesis; however, the prosthesis was fabricated with holes that corresponded to all of the other prosthetic components' locations (Fig 12). The remaining prosthetic components were to be attached to the provisional prosthesis with a clinical pick-up protocol.

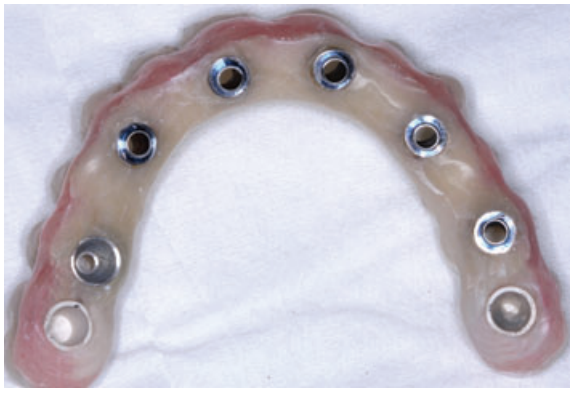

Figure 15 Intaglio surface of provisional prosthesis after it was finished and polished.

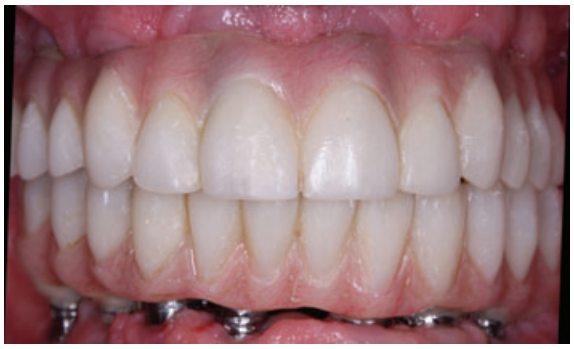

Figure 16 Intraoral anterior image of the patient at the 24-hour postoperative visit. Occlusion and tooth locations were consistent with the computed tomography-guided surgical treatment plan.

The first author decided that due to the large A/P spread, and coupled with the number of implants (8), it could be quite cumbersome to accurately pick up seven intraoral restorative components for an SRIP. Cement-retained components have more tolerances relative to fit between prostheses and implant fit than do screw-retained components. It was decided to use cement-retained components for the distal abutments of this full-arch prosthesis. The first author also thought it would be more likely for the prosthesis to fit accurately and passively by not using screw-retained components throughout the prosthesis.

On the day of surgery, the patient was anesthetized, and the surgical guide was fixed into place with fixation screws. A specific limitation of tissue-supported surgical guides is that positions of the guides may vary from the locations in the reformatted images and the actual locations clinically, as their 3D positions may be influenced by the amount of pressure exerted by the surgeon or patient in seating the surgical guides. This may slightly alter the positions of surgical guides prior to the clinical insertion of fixation screws. Guide orientation and position may also be influenced as implants are placed. The implants were placed according to the surgical treatment plan.

The surgical guide was removed and the prosthetic components were placed according to the prosthetic treatment plan (Fig 13). As mentioned previously, this specific prosthetic treatment included a combination of screw- and cement-retained components. The prosthesis went to place with the screw-retained cylinder in the right cuspid site; it was adjusted to make sure there were no interferences between any of the prosthetic components and the prosthesis. Occlusal contacts were adjusted such that they were evenly distributed throughout the

provisional prosthesis; the occlusal contacts were consistent with those developed in the laboratory on the articulator. The contralateral screw-retained implant temporary cylinder was placed into the maxillary left cuspid-site implant, and with the patient's mandible in centric occlusion, autopolymerizing acrylic resin (Jet Acrylic) was used to attach the cylinder to the provisional prosthesis. The resin polymerized, the prosthesis was removed, and excess resin was removed from the implant restorative platform of the temporary cylinder (Fig 14). Additional autopolymerizing acrylic resin was mixed and applied to the intaglio surface of the prosthesis and around the intraoral, screw-retained components; the prosthesis was screwed into the cuspid implants, and the patient was guided into centric occlusion. The resin was allowed to set. The prosthesis was removed; excess acrylic resin was trimmed from the screw-retained components. In similar fashion, the two distal cement-retained components were picked up with a new mix of autopolymerizing acrylic resin (Fig 15). It should be noted that combining cement- and screw-retained components during the prosthetic phase of treatment was cumbersome. The authors have concluded that it is not necessary to use both screw- and cement-retained components and now only use screw-retained components.

After polymerization, the prosthesis was removed, appropriate polishing protectors were placed onto their respective prosthetic components, and the prosthesis was finished and polished. Temporary cement (IRM, L. D. Caulk Division, Milford, DE) was mixed and placed along the margins of the distal retainers; abutment screws were used in the other prosthetic components. The abutment screws were torqued to 20 Ncm; screw access openings were blocked out with cotton and restored with light-cured composite resin (Fig 16). Postoperative periapical radiographs were taken of the two distal implants to ensure all the cement had been removed.

The patient was seen the next day and reported no problems; he was also quite pleased with the results. He was also seen 6 and 12 months postop; his physical findings continued to be within normal limits. Radiographs taken at the 12-month visit demonstrated satisfactory bone/implant contact with minimal crestal bone-level changes compared to the radiographs taken immediately postinsertion of the prosthesis.

Summary and conclusions

A limited review of the literature on IOL in edentulous jaws demonstrated high CSRs with both maxillary and mandibular dental implants. The reported survival rates were consistent with long-term survival rates reported with single- and two-stage unloaded, healing protocols. CT, CT treatment planning, and CT-guided surgery protocols, including reports as to the accuracy of planned implant placement versus the actual 3D positions implants were placed into, were also reviewed. CT-guided surgery is not 100% accurate; standard deviations of between 1 and 2 mm between planned and actual placement have been reported; surgeons must still use their expertise and clinical skills in placing implants with CT guidance. Finally, a clinical case was presented illustrating some of the clinical and laboratory phases of CT- and computer-guided treatment, including placement of a combined cement- and screw-retained, immediate provisional maxillary prosthesis. Clinicians must still use care, skill, and judgment in treating patients with IOL, CT treatment planning/CT-guided surgery, and immediate provisional prostheses.

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