Review Article

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Radiographic Stents For Implant Placement: A Review

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ABSTRACT

Background: Dental implantology has emerged as a practical alternative to traditional prosthodontics. Since the beginning, placement of implant in the bone to achieve a prosthetic solution that fulfills biologic, aesthetic and biomechanical requirements has been a challenge. In the past, implant site and inclination were dictated by residual bone quality. The desire for predictable prosthesis led to the development of prosthetically guided implantology. This concept establishes the correct implant position during the diagnostic stage according to planned definitive restoration. The use of guides for radiographic evaluation and surgical placement of dental implants can improve the final outcome of treatment for patients receiving implants. The purpose of this article is to describe procedures to construct precise radiographic stents. When used appropriately at the time of surgery, demands of the patient can be achieved.

Keywords: Radiographic stents, Dental implants, Osseointegration.

INTRODUCTION

Osseointegrated implants are a practical alternative to traditional prosthodontics; however, designing an implant-supported prosthesis with function and esthetics is a challenge[1]. Historically, surgeons placed implants where the greatest amount of bone was present, without regard to placement of the final restoration. This often led to a compromised final prosthesis with a jeopardized occlusal scheme and poor esthetics. Malaligned implants often complicate the clinical laboratory procedures employed for fabrication of superstructures. Due to improper load distribution, an overall increase in stress concentration on supporting structures may occur[2].

At first, implants were placed by use of simple periapical and panoramic radiographs. Acknowledgement that a surgical template would be helpful in more accurately placing the implants came soon thereafter. Although these early surgical templates added accuracy to implant placement, they were used only at the time of surgery for guidance during implant placement[3]. The relationship between the final prosthesis and osseous structures was not visualized before surgery, and often there was lack of bone where the templatewasdirectingthesurgeontoplacetheimplant [4]. The use of tomography[5] and computed tomography (CT)[6]provided practitioners with the ability to assess the quantity and quality of bone and critical anatomic structures before surgery. These advanced radiographic techniques allowed better bone evaluation. With CT scans, patients were scanned with an intra-oral template containing radiopaque markers indicating the relationship of availablebonetothefinalprosthesis[7].Any cone beam computed tomography (CBCT) scan intended for these purposes must include a scan prosthesis or integrate an optical scan of a diagnostically waxed cast. When the assembled 3-dimensional model

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(segmented maxilla, mandible, and prostheses) is visualized, available planning software enables improved planning and enhanced communication. The planned treatment can be used to direct computer aided design - computer aided manufacture fabrication of surgical guides that offer 3-dimensional control of implant placement.The main advantage of CBCT imaging is that a 3-dimensional image of the osseous region of interest may be constructed and viewed in multiple planes. Planning that leads to implant placement results in a reasonable level of accuracy as suggested by a recent systematic review.[8]

Use of CBCT imaging for dental implant treatment planning:[9-11]

- Determine the orientation of the alveolar ridge.
- Evaluate the morphology of the residual ridge.
- Identify anatomic features that could limit the implant fixture position.
- Evaluate pathologic conditions that would restrict the implant fixture placement.
- Match imaging findings to the restorative plan.
- CBCT is desired when there is a need for hard tissue grafting. It should be used to evaluate hard tissues after augmentation procedures have been performed.

A stent is an appliance used for radiographic evaluation of height and width of the available bone during treatment planning for implant placement or during surgical procedures to provide site for optimum implant placement.[12]

Requirements of a radiographic stent are:[13]

- Radiopaque indicator of correct tooth form and position without inducing scatter.
- Retentive and stable intraorally.
- Comfortable.
- Sterilizable, if used as a surgical guide.
- Compatible with scanner (hardware) platform.

Four different ways to produce a useful radiographic stent:

1. Use of an existing prosthesis containing radiopaque markers (Fig.1).
2. Use of a thermoplastic shim incorporating radiopaque markers (Fig.2).
3. Use of radiopaque teeth in a mucosa or tooth-supported stent (Fig.3).
4. Fabrication of a radiopaque resin duplicate of a prosthesis or a diagnostic wax-up (Fig.4 and Fig.6).

EXISTING PROSTHESIS

An existing prosthesis can be used as a radiographic stent and possibly a surgical guide. The tooth or teeth in the existing prosthesis should represent the intended position of the future implant-related prosthesis.Radiopaque markers are placed onto or within the prosthesis to achieve the scan. Immediately following scanning, the markers may be removed (Fig.1).

Advantage: The procedure is simple, direct and cost-effective

Fig 1: Existing prosthesis with gutta percha used as radiopaque markers.

The other three procedures require preliminary study casts that are mounted on anarticulator. Then, the planned position and form of the proposed prosthesis must be defined by denture tooth arrangement or diagnostic waxing methods. This is true of single-tooth, multiple-tooth (eg: implant-supported fixed dental prosthesis) or full arch restorations.

THERMOPLASTIC SHIM

After the establishment of tooth position (often verified clinically by a wax try-in or temporization), duplicate the study cast in dental plaster or stone. The estimated or desired location of implant is marked on the cast by drawing a line bisecting the intended tooth mesiodistally. Sticky wax is applied to this line, and a 0.5 mm wide strip of lead foil is applied to this position by rubbing with a warm wax spatula. The lead foil should extend from the midlingual position to the buccal cervical margin of the designated tooth. The cast is now placed onto the vacuformer platform, and a thermoplastic shim is formed directly onto the cast. The wax and the lead foil is transferred by the heat from the resin to the inner surface of the formed thermoplastic shim. The shim can be trimmed to the height of contour of the majority of teeth, whichenables ease of placement with sufficient stability during scanning and subsequent surgery. For single-tooth implants, a thin material of 0.5 to 0.75 mm can be used. However, as the extent of the edentulous area expands, a thicker material can be used to prevent flexing of the stent intraorally (Fig.2).

Advantage: Use of a thermoplastic shim incorporating radiopaque markers is a relatively inexpensive and rapid method of creating a radiographic stent that embodies the ideal feature.

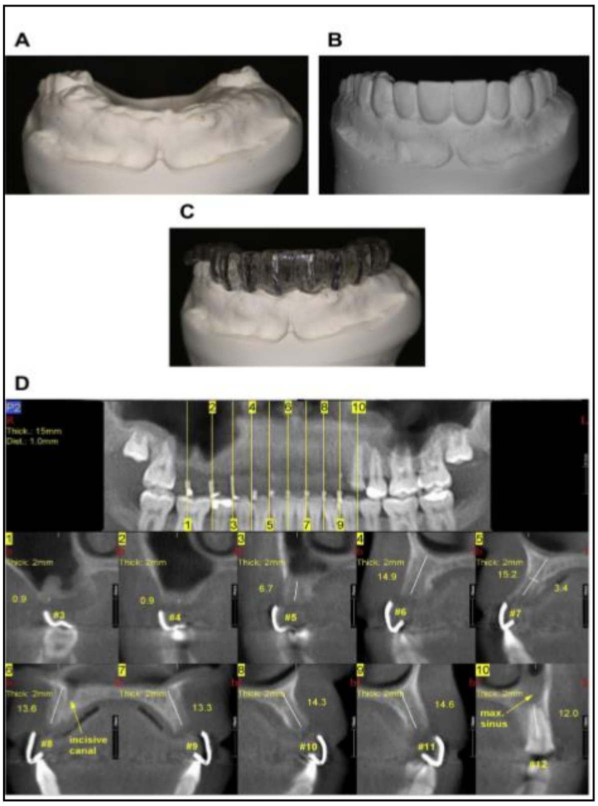

Fig 2: Use of a thermoplastic shim incorporating radiographic markers(A) Cast revealing missing anterior teeth. (B) The completed diagnostic waxing is duplicated in dental stone. (C) Lead foil strips applied to the stone cast are integrated into a thermoplastic stent. (D) The resulting CBCT image revealing the location of the planned prostheses and existing bone. [Image taken from Dent Clin N Am 58 (2014) 181–192]

RADIOPAQUE TEETH

After the accurate mounting of diagnostic study casts, the radiopaque teeth are adapted and placed onto the cast to represent the position of the planned implant-related prostheses with acknowledgment of the estimated position of the planned implant(s).

There are three ways of incorporating the radiopaque teeth into the radiographic stent:

1. The first follows the process described for the thermoplastic shim and by vacuum forming; the radiopaque teeth are retained within the stent (Fig.4).
2. The second way involves the use of composite baseplate material and requires hand forming of the tooth-supported guide using strips of this material adapted to the natural teeth and incorporating the radiopaque teeth within the formed guide.
3. A third method is the processing of the radiopaque teeth into either a partial or complete prosthesis. Inclusion of tissue bearing flanges adds to the stability and accuracy of the radiographic stent. When adopting this approach, the processed acrylic resin will be radiolucent unless a radiopaque alternative is used in the processing of the stent(Fig.3).

Advantage: The use of radiopaque teeth to create a surgical guide offers the advantage of displaying the complete 3-dimensional form of the tooth in the CBCT-generated volumetric image.

Fig 3: Use of radiopaque teeth. The incorporation of radiopaque teeth into a removable prosthesis is another strategy to visualize the prosthetic tooth position in the CBCT image.[Image taken from Dent Clin N Am 58 (2014) 181–192]

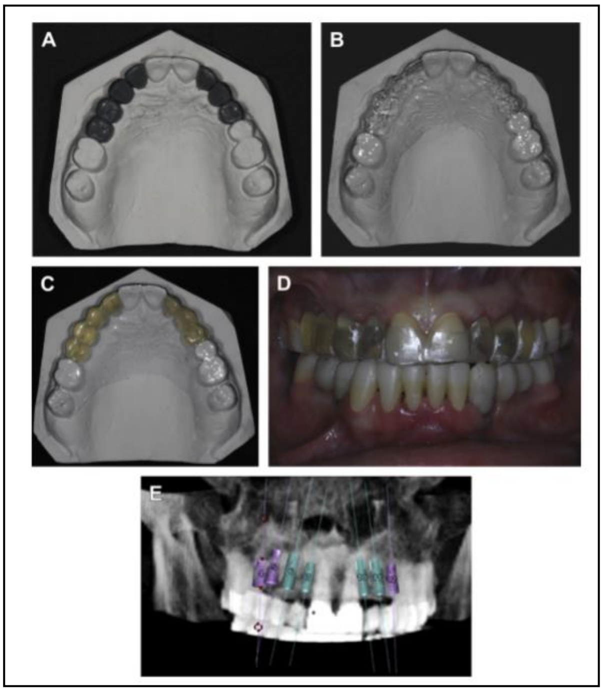

Fig 4: (A) Patient with the completed diagnostic waxing. (B) An acrylic thermoplastic stent. (C) Biocryl X is polymerized within the acrylic thermoplastic stent, creating a radiopaque duplicate of the diagnostic waxing. (D) The thermoplastic stent with radiopaque teeth in position, ready for CBCT scanning. (E) The resulting CBCT image revealing the process of implant planning in the derived 3-dimensional model that displays the position of the teeth and existing bone. [Image taken from Dent Clin N Am 58 (2014) 181–192]

RADIOPAQUE STENT

A radiopaque stent is necessary when mucosal surgical guides are utilized or when generating a plan by segementation method. In many edentulous (partial or complete) cases, wherethe eventual treatment plan will involve an implant-supported partial or complete overdentures, or will result in full arch prosthesis for the edentulous patient, it is often advantageous to complete the waxing of the partial or complete overdenture to verify phonetics, esthetics, and function. Another way of creating a radiographic template is by means of duplicating the partial or complete denture in a radiopaque resin. Two divergent scanning procedures are possible here.

1. One is an integrated scan that requires the denture to be duplicated in a radiopaque resin. The radiopaque denture is worn during the CBCT scanning procedure. The denture is duplicated in a duplicating flask or by using silicone putty in a clam shell technique (Fig.5).

2. The second approach is the dual scan technique, in which the dentures are scanned by CBCT, and the patient wearing the dentures is scanned by CBCT. Here, the denture must be a radiopaque (and geometrically) identifiable fiduciary markers distributed throughout the denture so that the denture may be aligned with the patient following the scanning procedure (Fig. 6). Some advantages of the dual scan technique include that the manipulation of the volumetric images is reduced in the process of generating a digital plan and the digital manufacture of a surgical guide.[14-18]

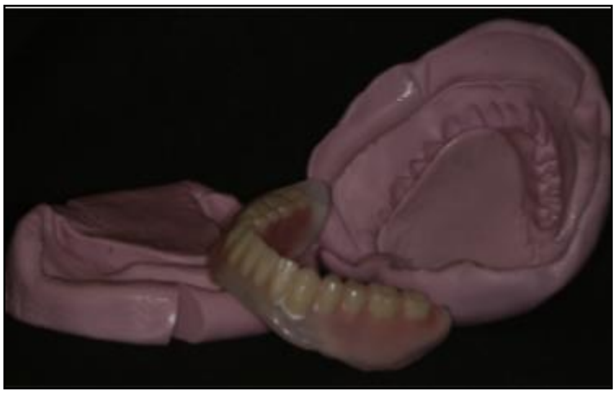

Fig 5: The duplication of a denture is completed using silicone laboratory putty in a clam shell technique. [Image taken from Dent Clin N Am 58 (2014) 181–192].

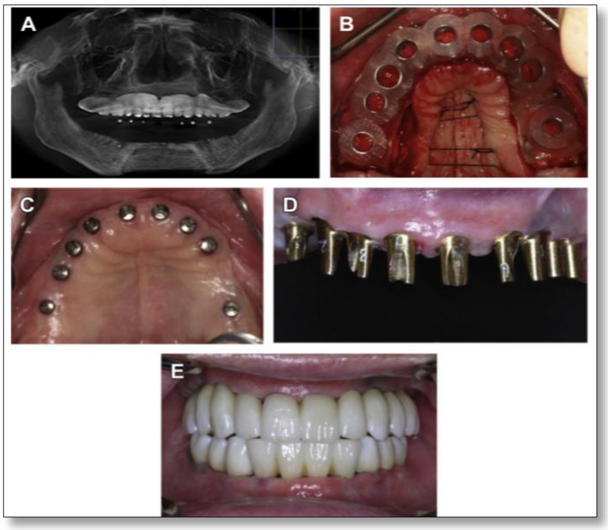

Fig 6: (A) CBCTscan produced using a radiopaque resin - a duplicate. (B) Stereolithographic surgical

guide produced from the CBCT-derived treatment plan (C) Resulting implant placement revealed by 1 stage surgery outcome at 4 weeks. (D) Position of CAD-CAM abutments on implants indicates achievement of implant position for FDP construction. (E) Final maxillary and mandibular FDPs supported by dental implants placed using. [Image taken from Dent Clin N Am 58 (2014) 181–192].

SUMMARY

The use of volumetric imaging is emerging as a valued aid in planning, placement, and restoration of dental implants. Any CBCT scan intended for these purposes must include a scan prosthesis or integrate an optical scan of a diagnostically waxed cast. When the assembled 3-dimensional model (segmented maxilla, mandible, and prostheses) is visualized, available planning software enables improved planning and enhanced communication. The planned treatment can be used to direct CAD-CAM fabrication of surgical guides that offer 3-dimensional control of implant placement. Ongoing development enables clinicians to design and manufacture patient-specific abutments within this 3-dimensional virtual environment to further streamline and improve planning and treatment. Clinicians should understand fully the advantages of this technology to appropriately prescribe CBCT scanning for dental implant treatment planning and therapy.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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