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Research Article

Radiopacity of Dental Materials used for Imaging Guides in Implant Dentistry

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Abstract

Objective: The purpose of this study was to measure the radiopacity of different biomaterials which can be used to fabricate radiographic guides for cone beam computed tomography imaging. Radiographic guides are an essential step in the sequence for accurate treatment planning for implant dentistry. An imaging stent helps guide the clinician determine the final three-dimensional placement of dental implants. There are different materials that can be used for this application. Fabrication of a radiographic guide depends on the proposed definitive restoration or prosthesis.

Study: 6 dental materials (barium sulfate, gutta percha, TempBond NE cement, bisacryl provisional material, urethane dimethacrylate tray material and vinylpolysiloxane) with a metal rod as control were chosen. They were divided into 11 standardized samples and radiographic imaging was carried out. Radiopacity was visually evaluated and accordingly ranked in descending order.

Results: All materials displayed varying degree of radiopacity relative to the metal rod. 100% barium sulfate, TempBond NE and gutta displayed similar levels of radiopacity compared to the other samples. Urethane dimethacrylate and vinylpolysiloxane displayed decreased radiopacity with laboratory putty displaying the least radiopacity.

Conclusions: Several radiopaque biomaterials are available to be used for radiographic guides in implant dentistry with barium sulfate, gutta percha and TempBond displaying the highest levels of radiopacity in this study.

Keywords: *Radiographic Guide; Radiopacity; Dental Implants; Cone Beam Computed Tomography*

Introduction

One of the most important steps in treatment planning for dental implants is determining the correct three-dimensional position of the implant. Accurate horizontal and vertical placement of the implant is essential for optimum hard and tissue harmony and esthetics. Periapical and panoramic radiographs are useful low radiation dose imaging techniques but are two-dimensional in nature. Panoramic radiographs are commonly used as a diagnostic imaging tool but are known to have inherent horizontal and vertical magnification errors [1,2]. Cone beam computerized tomography (CBCT) scan is the gold standard in radiographic imaging for dental implants [3,4]. CBCT imaging is essential in all stages of treatment including pre-treatment assessment, implant placement and post-treatment evaluation of longevity [5].

A radiographic guide is invaluable when it comes to relating the proposed tooth position and emergence profile to the available bone. These templates can later be converted to surgical guides for implant placement. Radiographic guides can vary in their fabrication depending on the extent of the edentulous span and the definitive restoration/prosthesis. Several materials have been reportedly used for fabrication of such guides including but not limited to: lead foil, gutta percha, metal sleeves, barium sulfate, radiopaque denture teeth and radiopaque acrylic resin [6-8]. The basic steps in fabrication include preliminary impressions, articulation of diagnostic casts followed by a diagnostic wax-up or artificial tooth arrangement. The casts or prostheses are then duplicated in radiopaque material or with radiopaque markers for the CBCT scan. Important features of radiographic guides [7] include:

1. Relative ease of fabrication
2. Radiopaque markers
3. Ability to be disinfected
4. Comfortable for patient and stable during the imaging process
5. Represent the final tooth/prosthesis position inciso-cervically, bucco-lingully and mesio-distally
6. Markers which adapt to soft tissues well in order to plan for proper emergence profile of the restoration
7. Ability to be converted to a surgical guide
8. Compatible with scanning software
9. Cost-effective

Radiopaque is defined as a structure that strongly inhibits the passage of radiant energy [9]. Several reports have studied the degree of radiopacity of restorative materials in relation to human tooth structure [10-13]. The materials mainly studied were luting agents, endodontic sealers, direct restorative materials and non-metallic CAD/CAM restorative blocks. Reports have also been published regarding different techniques and materials for radiographic guides, but a side-by-side comparison of different radiopaque materials has not been studied.

Purpose of the Study

The purpose of this article was to identify dental materials that can be used for radiographic guide fabrication, taking into consideration: degree of radiopacity, availability and cost.

Materials and Methods

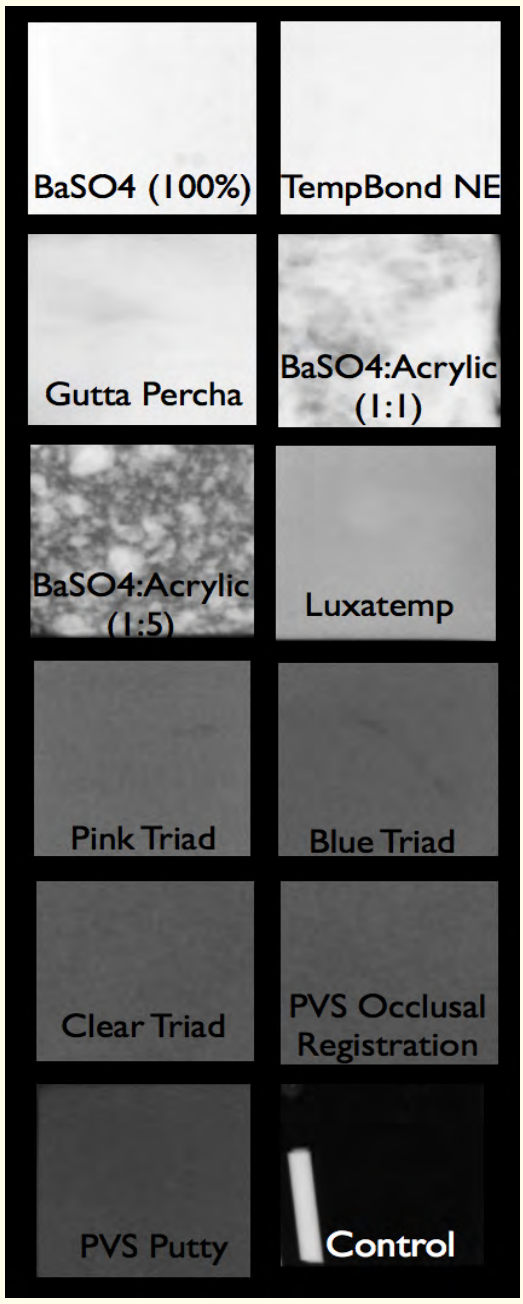
Commonly available dental materials were chosen for this study: barium sulfate (American Dental Supply, Allentown, PA, USA), gutta percha (Coltene/Whaledent, Cuyahoga Falls, OH, USA), TempBond NE cement (Kerr Dental, Orange, CA, USA), bisacryl provisional material (Luxatemp Automix Plus, DMG America), urethane dimethacrylate tray material (Triad VLC, Dentsply, USA) and vinylpolysiloxane (VPS) occlusal registration material (Classic Blue-mousse, Parkell Production Inc, Edgewood, NY, USA) with metal rod as a control. These potentially radiopaque materials had to be separated by a radiolucent medium. Hence, baseplate wax was chosen for that purpose. A standardized wax container was formed and into which these materials were distributed into 11 standardized samples of 5 mm thickness to simulate intra-oral conditions. The samples were prepared as follows (Figure 1 and 2):

1. Barium sulfate paste (100%): Barium sulfate powder was mixed with water to form a thick paste.
2. Barium sulfate + acrylic resin (1:1 ratio): Barium sulfate was mixed with clear polymethylmethacrylate powder and liquid in a 1:1 ration to form a radiopaque mixture.
3. Barium sulfate + acrylic resin (1:5 ratio): Barium sulfate was mixed with clear polymethylmethacrylate powder and liquid in a 1:5 ratio to reduce the relative radiopacity.
4. Gutta percha: Several gutta percha cones were warmed with a flame and packed into the container.
5. TempBond NE: Zinc oxide based non-eugenol cement was utilized.
6. Bisacryl provisional material (Luxatemp, DMG America): Auto-polymerizing bisacryl material was utilized.
7. Urethane dimethacrylate (UDMA) - Pink (Triad, Dentsply USA): UDMA was placed into the container and polymerized with an ultraviolet curing light.
8. Urethane dimethacrylate - Blue (Triad, Dentsply USA): UDMA was placed into the container and polymerized with an ultraviolet curing light.
9. Urethane dimethacrylate - Clear (Triad, Dentsply USA): UDMA was placed into the container and polymerized with an ultraviolet curing light.
10. Vinylpolysiloxane: A high viscosity occlusal registration material was utilized.
11. Laboratory putty: A condensation silicone putty was hand-mixed and placed in the container.

Care was taken to properly pack the materials into the compartments for better radiographic image quality. Standardized digital radiographs were taken at the same mA and kVP settings for uniform exposure of the materials. The radiographs were exported as JPEG files and made ready for evaluation in order of radiopacity.

Results

Radiographs from the samples were checked for flaws such as poor quality, cone cuts, proper contrast, etc. No retakes were necessary. Radiopacity was visually evaluated and ranked accordingly. The radiopacity of the different samples is seen in Figure 3. 100% barium sulfate, gutta percha and TempBond NE were seen to have higher radiopacity than other materials relative to the control. Barium sulfate combinations (1:1 and 1:5) with acrylic resin yielded high radiopacity but the mixture was not homogenous. Bisacryl provisional material had lower radiopacity than barium sulfate, gutta percha and TempBond NE, but higher radiopacity when compared to urethane dimethacrylate and vinylpolysiloxane with laboratory putty having the least radiopacity.



Discussion

The above-mentioned materials are readily available in a dental office or University setting. They can be appropriately used for radiographic guide fabrication. Barium sulfate is available in powder form which can be mixed with clear acrylic resin to form a paste and placed in a thermoplastic shell generated from a diagnostic wax-up. Radiopaque barium teeth are supplied by some manufacturers which can be processed with clear bases for CBCT imaging (Figure 4 and 5). Although the quality of the scan is very good with these teeth, this method adds time and cost to the process. Gutta percha is one of the simplest materials to use as it can be applied over existing prostheses or inserted into circular channels and over the tooth surfaces in the radiographic guide as markers. They indicate implant trajectory and tooth form.

Bisacryl material can be used in a variety of ways depending on the final prosthesis. For single and multiple implant restorations, it can be injected into the thermoplastic shell and relined on the diagnostic cast whereas for full arch prostheses, it can be used with a denture duplicator. The material is injected into the tooth areas of the duplicate mold (Figure 6). The rest of the prosthesis is then relined with auto-polymerizing clear acrylic resin. Circular channels are drilled into the teeth. The CBCT scan will show the radiopaque teeth over the alveolar ridge and the channels will appear radiolucent. Urethane dimethacrylate, VPS and laboratory putty are materials that can be inserted into the thermoplastic shell and used for imaging. Lead foil is another option that can used in the form of strips over the teeth and ridge lap areas of the teeth on the radiographic guide.

Summary

Radiographic guides are an integral part of dental implant therapy. Their accuracy is of paramount importance to plan the final position of the implant and corresponding restoration. Currently there are several materials and techniques used for fabrication of radiographic guides. Although, computer generated guides exist and have proven to be very accurate there are several materials available which can be used chair-side. One of the most commonly used method is duplication of the prosthesis and placement of radiopaque markers like barium sulfate and gutta percha. This article shows that there are other readily available biomaterials the clinician has access to and the choice depends on the type of definitive restoration/prosthesis.

Conflict of Interest

None.

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