Effect of prosthodontic planning on intercuspal occlusal contacts: Comparison of digital and conventional planning

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ABSTRACT

Background: Adequate occlusal contacts are critical for masticatory function. The aim of this study is to evaluate the intercuspal occlusal contacts following conventional and digital wax-ups.
Methods: Stone casts of 15 patients undergoing prosthodontic treatment were gathered. Each cast was duplicated twice, so that conventional and digital wax-ups could be performed. To assess the occlusion, the following variables were evaluated: contact number per tooth (CNT), contact area per tooth (CAT) and contact accuracy. Further, the impact of tooth location in the arch was assessed.
Results: The CNT and CAT after the wax-ups increased significantly following each wax-up, and this increase was more prominent for the posterior teeth than the anterior teeth. The conventional wax-up was associated with lower CNT than the digital wax-up, especially for the posterior teeth. On the other hand, the CAT was greater for the conventional wax-up than the digital wax-up for the anterior and posterior teeth. In terms of accuracy, the two wax-ups showed greater discrepancies than the pre-treatment casts, however, the magnitude of discrepancy was greater for the digital wax-up.
Conclusions: The two wax-ups improved the contact number and area. Despite the statistical variation between the wax-ups, the actual difference was minimal. Therefore, it could be speculated that the two wax-ups produced a similar outcome.

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1. Introduction

In many instances, diagnostic wax-up is advocated to determine the viability of any proposed prosthodontic treatment [1,2]. The wax-up is a useful tool for selecting the ideal treatment, enhancing communication with the patient and for provisional restoration construction. Subsequently, a good wax-up will dictate the final prosthesis fabrication [1]. Any diagnostic wax-up should be accurate, aesthetic and feasible. Traditionally, the tooth surface is designed with a conventional wax-up technique as part of prosthodontic planning. The tooth contour and occlusion are modified by the addition of wax on the external tooth surface [2]. Recently, virtual designing of the tooth surface with digital techniques was proposed as an alternative method for prosthodontic planning [3]. It entails altering the tooth contour of a virtual stone cast. To facilitate the contour alterations,

several authors had proposed applicable approaches and algorithms [4–7]. To ensure the usability of the digital wax-up, the alteration process is followed by production of a physical cast by subtractive of additive computer aided manufacturing [8]. Alternatively, provisional restorations can be produced according to the digital wax-up [9].

The digital wax-up has the advantages of not permanently altering the stone cast, quantifying the dental modifications, simplicity of execution, and the possibility of trying different treatments. Further, as the digital wax-up is performed using specialised software, more clinicians can provide a wax-up, even without artistic technical abilities. However, the digital wax-up should at least exhibit a similar accuracy to conventional wax-up.

Regardless of the type of diagnostic wax-up, the static and dynamic occlusal contacts should be of adequate quality and accuracy. The occlusal contacts will eventually contribute to the functional benefit and comfort of the prosthesis [10,11]. Experimentally, the quality of the occlusal contacts can be determined by the number of contacts, the area of the contacts and the accuracy of the contacts. Therefore, the aim of this study is to evaluate the effect of the conventional and digital wax-ups on occlusal contacts in terms of number, area and accuracy. The null hypotheses are that the wax-ups will alter the occlusal contacts and that there is

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no difference in occlusal contacts between the conventional and virtual techniques in designing of the occlusal surface.

2. Materials and methods

A human research ethics approval was granted from the Human Research Ethics Committee of the University of Western Australia (RA/44/1/5079). Stone casts of 15 patients who required fixed prosthodontic treatment were retrieved for the study. The inclusion criterion was necessity of diagnostic wax-up prior to prosthodontic treatment that will influence the dental occlusion. The patients were under care at the Oral Health Centre of Western Australia.

For each arch, an irreversible hydrocolloid impression (Alginate, GC America, IL, USA) was made. An occlusal relation record was obtained using polyvinyl siloxane registration material (GC Exabite, GC America, IL, USA) according to the centric relation position. The impressions were poured by type III dental stone (Buff Stone, Adelaide Moulding & Casting Supplies, South Australia, Australia). These casts comprised the pre-treatment casts. All the casts were duplicated twice by reversible hydrocolloid duplicating materials (Magafeel, MKM System, Haanova, Slovakia). One cast received conventional wax-up and the other cast was used for the digital wax-up (Fig. 1).

2.1. Conventional wax-up

Semi-adjustable articulator (Whip Mix, Louisville, KY, USA) with pre-determined values was used in this study for the wax-up as advised by some authors [12]. One set of casts were articulated according to the maximal intercuspation position and the other set of casts were articulated according to centric relation position with the aid of the intra-oral record. The maximal intercuspation position was used to relate the pre-treatment casts. This position will reflect the habitual relationship which is more relevant for function prior to the treatment [13]. On the contrary, the centric relation position was used to relate the arches prior to the wax-ups. Therefore, after the wax-up, there will be a coincidence between centric relation and maximal intercuspation positions [13]. Following the articulation, silicone material putty (Dental Speedex Putty, Coltene/Whaledent AG, Altstatten, Switzerland) was applied on the buccal aspects of the posterior teeth of the mounted casts. This silicone index was used for the digital articulation of the pre-treatment casts.

The conventional wax-up was completed by inlay wax (VITA Zahnfabrik, Bad Sackingen, Germany) addition on the external tooth surface. In some areas, the external tooth surface was modified by trimming. The wax-up aimed to rectify the defective tooth structure, establish natural and aesthetic tooth morphology, and achieve symmetry between the two sides. As the occlusion of all the teeth were altered, the alteration mechanism involved obtaining even bilateral occlusal contacts and a physiological lateral occlusal scheme (canine-guided or group function occlusion) [13,14]. All the conventional wax-ups were completed by an experienced dental technician. On the completed wax-up casts, silicone indices were formed on the buccal aspect of the posterior teeth.

The pre-treatment and conventional wax-up casts and the associated silicone indices were scanned by a Micro-CT scanner (SkyScan, Bruker micro CT, Kontich, Belgium) (12 μm resolution, 360° scanning, 70 KV source voltage, 1.0 mm Al filtration). The reported advantage of Micro-CT scanning is the possibility of producing an accurate image that exhibits a dimensional error of 0.1% [15]. Subsequently, virtual 3D Stereolithography (STL) images of the maxillary and mandibular casts were constructed from the Digital Imaging and Communication Medicine (DICOM) images
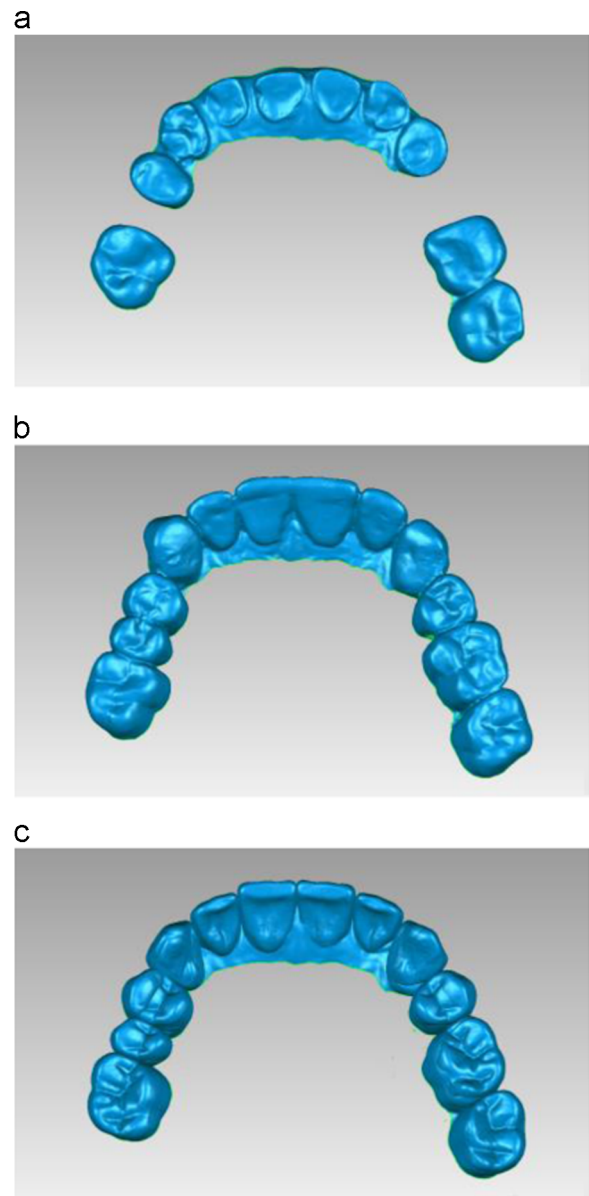

Fig. 1. Example of the virtual pre-treatment (a), conventional wax-up (b) and digital wax-up (c) casts.

using a DICOM viewing programme (CTvox, Bruker microCT, Kontich, Belgium). The construction procedure was based on model surface extraction from the stacked series of DICOM images. The virtual image of the conventional wax-up was used for the subsequent analysis (Fig. 1b).

The virtual silicone indices were used to articulate the pre-treatment and the conventional wax-up casts digitally, using the process of image registration as illustrated by DeLong et al. [16]. A 3D rendering software package (Geomagic Studio, Raindrop Geomagic Inc., www.geomagic.com, Research Triangle Park, NC, USA) was used for the registration process. The purpose of the registration process is to precisely align the models that share common surfaces. As discussed by several authors [17], the registration process involved two sequential steps: (1) point-to-point registration and (2) global registration. The point-to-point registration is based on coarse registration between two similar surfaces. This step was completed manually by selecting points on common surfaces of the virtual cast and the silicone index. As a result, the virtual models translate spatially until they reach a reach position. In this experiment, the cusp tips and the most cervical gingival