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Comparison of non-invasive radiographic measurements of soft tissue in the interdental space: a cadaver study

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Abstract

When we use implants the aesthetic appearance of the patient is dependent to a large extent on identification of factors that influence the presence of interdental papillae. The aim of this study was to compare the accuracy of different non-invasive measurements to indicate the top of the interdental papilla on dental radiographs. The sample comprised six fresh, partly edentulous cadavers. The distance from the level of the interproximal bone next to the tip of the papilla was measured (n = 330) on standard radiographic images. Five different mixtures of radiopaque markers that had been used to highlight the top of the papilla in recently published studies were analysed. All measurements were compared with the bone probing length, which was evaluated clinically. The mixture of zinc oxide, eugenol cement, and tungsten powder (mean (SD) 0.14 (0.17) mm) deviated least from the control value. The deviation was significant ($p < 0.01$) between the zinc oxide, eugenol cement, and tungsten powder mixture and each of the other individual combinations. The most accurate non-invasive radiographic method of measuring the interproximal length of the papilla relative to the alveolar bone crest was therefore the mixture of zinc oxide, eugenol cement, and tungsten powder.

Keywords: Soft tissue; Noninvasive measurement; Interproximal papilla; Radiography

Introduction

For a long time it has been commonplace when teeth have been lost to treat both functional and aesthetic aspects with dental implants and it has been professionally challenging, particular at the front. The position of each individual implant in the jaw has an effect on the peri-implant bone crest and margin of soft tissue. Several authors have evaluated important soft and hard tissue landmarks around the teeth and implants for the development of the papilla and the amount of alveolar bone.[1–3] These landmarks include the first contact of crestal bone with the implant, the level of bone at the neighbouring tooth, the bone crest, and the top of the interdental papilla.[3,4] The most important landmark, the top of the tip of the papilla in the interdental space, has been investigated by several workers.[2,3,5–12] Kan and Kwon[6,7] described the relation between the height of the papilla and the interproximal bone next to the adjacent teeth.

If the papilla is non-existent, and the gingiva has recessed because the implant is in a unsatisfactory position, results are poor and include longer crowns, or the appearance of the root

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of a tooth or the dark grey titanium shoulder of the body of an implant.[3,13] At its worst the lack of formation of a papilla may lead to a so-called "black triangle" in the interdental space, which is unpleasant for patients,who develop visible soft tissue linings or even "gummy" smiles.[14]

Currently there are several invasive and non-invasive techniques that permit the measuring of the distances between these landmarks to describe the individual patient's soft and hard tissue topography. A recent multicentre study emphasised that there was a need for a technique to permit the unbiased and metric assessment of implant-related dimensions of soft and hard tissues.[15] Some of these landmarks can be evaluated only with the aid of radiographs, but others can be measured directly.

We made invasive measurements in a clinical investigation in which a "sounding" (a forced probing measurement of the depth of the bone crest or an operative re-entry using a mucoperiostal flap) are exact metric measurements of the height of the papilla.[16] Disadvantages of taking a sounding are the need for anaesthesia and traumatic access through the peri-implant gingival, which risks recession of soft tissue at the gingival margin.

All non-invasive methods use radiodense markers that show the top of the interdental papilla in the right-angle of the standard radiographic image. Several authors have described four different radiodense mixtures: zinc phosphate cement and barium sulphate; calcium hydroxide polymeric sealant; zinc oxide, eugenol cement, and barium sulphate; and zinc oxide, eugenol cement, and tungsten powder.[1,4,10,12] One non-invasive method visualised the top of the papilla radiograpically by pointing a wire at its tip.[2]

However, we know of no papers that have described which of the different techniques is the most precise and user-friendly for marking the top of the papilla. The aim of this study, therefore, was to compare the accuracy of the four different non-invasive measurements of the top of the papilla in the interdental space.

Material and Methods

All cadavers used in this investigation were obtained from the Department of Anatomy of the University Hospital. Cadavers with normal teeth, dental fillings, and crowns were included. The guidelines of the Declaration of Helsinki were followed throughout the investigation.

The measurements made radiographically included the length of the papilla and the bone probing length for each interproximal site. The length of the papilla was measured from the point of contact with the bone at the tooth to the tip of the papilla. To analyse this we used four different radiodense mixtures to mark the top of the papilla, and a ligature wire pointed at the top of the papilla (Table 1).

The radio-opaque material was put in place with no pressure on the soft tissue (Fig. 1). Using this radiodense marker, a right-angled standard radiograph showed a clear, sharp delineated negative image of the top of the interdental papilla, or (in case of the ligature wire) pointing exactly at the top of the papilla.

Fig. 1. Marking the tip of the papilla with the radiodense mixtures.

While the radiograph was being taken, a standard radiographic grid (Rinn XCP®, Dentsply Corporate, USA), at a defined distance from the objective, combined with an occlusal silicone bite block (Silaplast Futur, Detax GmbH & Co. KG, Germany) was applied to the sensor. The standard radiograph was obtained at a 90° angle to the axis of the papilla on a computer screen. The identification of the tip of the papilla allowed measurement of the length of the papilla on standard dental radiographs.

The length of the papilla was measured on the radiograph as the distance between the interproximal bone at the teeth to the base of the radio-opaque material using a computer-aided software device. To calibrate the radiographic images, we used a gutta-percha point (ISO 40, Coltene GmbH, Germany) with a defined length of 5 mm. For digital measurements on the images, we used the software MB-Ruler (EOS-Metrology, Heidenheim, Germany). This software allowed us to place the endpoints of the measurements of distance in enlarged pictures with the aid of a loupe function that has a magnification x 2–16 (Fig. 2).

The clinical bone probing length was used as a control value of the distance from the crest of the bone to the tip of the papilla. A Williams graduated periodontal probe was inserted from the tip of the papilla until the examiner felt strong resistance (Fig. 3). The same examiner made all the measurements, and each one was made three times and the mean value taken. All distance values were rounded off to the nearest 0.5 mm.

Statistical analysis

Statistical analyses were made with the aid of the software IBM SPSS Statistics for Windows (version 22, IBM Corp, Armonk, USA) and we used the paired Student's t test. Probabilities of ≤ 0.05 were accepted as significant. All mea-

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