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ScienceDirect
British Journal of Oral and Maxillofacial Surgery 54 (2016) 980–986
BRITISH Journal of Oral and Maxillofacial Surgery
www.bjoms.com

# Effects on primary stability of three different techniques for implant site preparation in synthetic bone models of different densities

S.C. Möhlhenrich [a,b,*], K. Kniha [b], N. Heussen [c], F. Hölzle [b], A. Modabber [b]

[a] *Department of Orthodontics, University Hospital of Aachen, Pauwelsstraße 30, 52074 Aachen, Germany*
[b] *Department of Oral and Maxillofacial Surgery, University Hospital of Aachen, Pauwelsstraße 30, 52074 Aachen, Germany*
[c] *Department of Medical Statistics, University Hospital of Aachen, Pauwelsstraße 30, 52074 Aachen, Germany*

Accepted 5 July 2016
Available online 22 July 2016

**Abstract**

Preparation of implant sites affect the primary stability of implants that is necessary for osseointegration. We have investigated the effect on the primary stability of implants of three techniques used to prepare the site for implants in synthetic bone models of different densities. A total of 540 implants of varying diameters (3.3 (narrow), 4.1 (standard), and 4.8 (wide) mm) and lengths (8 or 12 mm) were inserted into three artificial bone blocks (the density of which decreased from D2, D3, to D4), and we compared conventional, fully-guided, and condensing preparation of the site. After insertion, primary stability was measured using resonance frequency analysis. There were significant differences between conventional and condensing procedures ($p < 0.0001$ in all cases) and between fully-guided and condensing procedures ($p < 0.01$ in all cases), but there were no differences between fully-guided and conventional procedures when short implants were used, with a standard or wide diameter in low-density bone blocks (D3 and D4). In low-density bone blocks (D3 and D4) wide implants (4.8 mm) compared with narrow (3.3 mm) resulted in significantly better primary stability ($p < 0.0001$ in all cases). Fully-guided preparation of the implant site is associated with increased primary stability, but is not an alternative to bone condensing. Use of longer or wider implants can increase primary stability, but the effect is less pronounced after bone condensing.


*Keywords:* Dental implants; primary stability; bone density; bone condensing; full-guided surgery; implant site preparation

## Introduction

Primary stability is important for successful treatment with dental implants. Low values indicate a high risk of early failure, and good primary stability indicates optimal conditions for osseointegration because it allows smaller micromotions between the implant and the bone. [1] Different methods have been described to monitor the stability of an implant. High values of insertion torque, resonance frequency analysis, percussion energy response, or removal torque indicate good stability, while low values indicate lack of stability. However, comparisons between these measures are still controversial. Studies have shown that resonance frequency analysis is the only method that detects the significant effects of various factors on primary stability.[2]

Interspecies bone quality is a confounding variable, and several classifications for bone density have been recommended. According to that described by Misch,[3] bone quality can be classified into four types (1–4), and there have been

* Corresponding author. Department of Oral and Maxillofacial Surgery, RWTH Aachen University Hospital, Pauwelsstraße 30, 52074 Aachen, Germany. Tel.: +0049 241 8080844; fax: +0049 241 8082430.
*E-mail address:* smoehlhenrich@ukaachen.de (S.C. Möhlhenrich).

http://dx.doi.org/10.1016/j.bjoms.2016.07.004
0266-4356/

reports of failure of implants of about 3% after insertion of implants into bone types 1, 2, or 3, and of 35% after insertion into bone type 4.[4] In addition, primary stability is lower in type 4 bone than in types 1-3.[5] Different studies have therefore used artificial bone substitutes such as homologous foam to eliminate the effect of interspecies bone quality.[6]

Several factors other than the density and dimension of the bone surrounding the implant can affect the success of dental implantation, including the design of the implant and the technique used. The design and surface of the implant (as well as diameter) may also affect the primary stability.[7]

There are various ways to prepare the site of the implant that can increase the primary stability, particularly in low-density bone. Friberg et al recommended the use of undersized drilling (the drill having a smaller diameter than that of the implant) to optimise bone density and subsequently stability.[8] Summers et al proposed the use of a bone condensing technique using condensers after a pilot drill to displace the bone at the periphery of the cavity.[9]

Osteotomies of the bed of the implant can be made using different techniques, such as freehand (without guidance), half-guided (with a sleeve), and fully-guided (using combinations of drill and tube to guide the drill, with sleeves based on a virtual planned implant osteotomy).[10] Templates transfer the exactly planned position into clinical reality and allow fully-guided preparation of the implant site with great accuracy.[11] This affects smaller bone cavities and could lead to smaller micromotions between the implant and the bone and better primary stability.[12]

The aim of this study was to find out whether changing the surgical technique for preparing the site of the implant (conventional freehand drilling, fully-guided procedure, and condensing), as well as the diameter and length of the implant result in better primary stability in different artificial bone densities (decreasing density from D2, D3, to D4).

## Material and methods

The site of the implant was prepared using three artificial bone blocks (#1522-03, #1522-01, and #1522-23; Sawbones, Malmö, Sweden). The American Society for Testing and Materials has approved the use of this material and has recognised it as a standard for testing orthopaedic devices and instruments, which makes it ideal for comparative testing of bone screws (ASTM F-1839-08). Solid rigid polyurethane foam blocks were classified according to their density as D2 (0.32 g/ml), D3 (0.16 g/ml), and D4 (0.08 g/ml).

A total of 540 implants, 10 implants in each group with different diameters of 3.3 (narrow), 4.1 (standard), or 4.8 mm (wide) and 8 or 12 mm long (Bone Level, Institut Straumann AG, Basel, Switzerland) were inserted in each artificial bone block by using one of the three techniques (conventional freehand, fully-guided, or condensing). The implants have a cylindrical outer contour with a conical core diameter and a thread pitch of 0.8 mm that tapers off in the coronal part of the implants and rough surfaces.

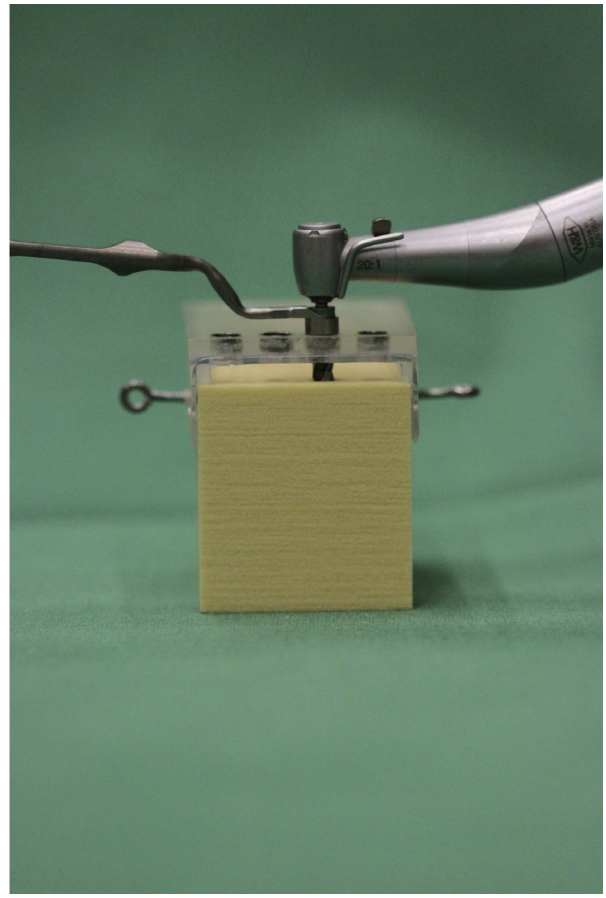


Fig. 1. Self-constructed template for full-guided preparation of the implant site on an artificial bone block with guided drills and tube-in-tube system.

Multiple step burs with increasing diameters were used for conventional and fully-guided procedures with surgical pilot and twist drills 2.2, 2.8, 3.5, and 4.2 mm in diameter to prepare implant beds 8 and 12 mm deep. Fully-guided preparation of the site was based on the instructions given in the Straumann Guided Surgery kit (Institut Straumann AG, Basel, Switzerland) that includes guided drills with depth control, and drill handles based on a tube-in-tube system (Fig. 1). For condensing preparation of the site we used condensers (Institut Straumann AG). After pilot drilling to a diameter of 2.2 mm and a length of 8 or 12 mm, the local bone was displaced into the periphery by osteotomes with increasing diameters of 2.8, 3.5, and 4.2 mm (Fig. 2). Finally, implants with diameters of 3.3, 4.1, or 4.8 mm and 8 or 12 mm long were inserted (Straumann Bone Level; Institut Straumann AG) depending on the technique, with (for fully-guided) or without (for conventional and condensing procedures) additional guidance.

After insertion of the implant, primary stability was measured using resonance frequency analysis with hand-screwed smart pegs (type 53 and 54; Ostell, Gothenburg, Sweden). Each measurement was expressed as the implant stability