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Review

Heat generation and drill wear during dental implant site preparation: systematic review

S.C. Möhlhenrich [a,*], A. Modabber [a], T. Steiner [a], D.A. Mitchell [b], F. Hölzle [a]

[a] Department of Oral and Maxillofacial Surgery, University Hospital of Aachen University, Pauwelsstraße 30, 52074 Aachen, Germany
[b] Maxillofacial Unit, Bradford Teaching Hospitals NHS Foundation Trust, St Lukes, Hospital, Little Horton Lane, Bradford, West Yorkshire BD5 0NA, England, UK

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Abstract

To identify factors that minimise damage during the drilling of sites for dental implants, we reviewed published papers on the amount of heat that is generated. We systematically searched English language studies published between January 2000 and February 2014 on MEDLINE/PubMed and found 41 articles, of which 27 related to an increase in temperature during preparation of the site. We found only basic research with a low level of evidence. Most of the studies were in vitro, and osteotomies were usually made in non-vital bone from cows or pigs. To measure heat in real time, thermocouples were used in 18 studies and infrared thermographs in 7. Three studies reported the use of immunohistochemical analysis to investigate immediate viability of cells. The highest temperature measured was 64.4 °C and the lowest 28.4 °C. Drill wear was reported after preparation of 50 sites, and there was a significant increase in temperature and a small change in the physiological balance of the proteins in the bone cells. Differences in the study designs meant that meta-analysis was not appropriate. For future work, we recommend the use of standard variables: an axial load of 2 kg, drilling speed of 1500 rpm, irrigation, standard artificial bone blocks, and the use of infrared thermography.

Keywords: Heat generation; Implant site preparation; Irrigation methods; Osseous models; Infrared thermography; Thermocouple

Introduction

Heat that is released during the preparation and insertion of implants could have consequences for the bone, and it has already been shown that the extent of the necrotic zone around the preparation site is proportional to the amount of heat generated.[1] Repeated use causes drills to wear and reduces their efficiency, and the temperature increases each time a bur is used.[2] Other variables may also affect their cutting ability and the amount of heat generated. Preparation of the site is a complex process and the shape, sharpness, and speed of the drill, applied axial load, and the density of the bone all have an effect.[3–7]

To our knowledge, the only review of this subject was published in 1999 by Tehemar who tried to identify all the factors that influence the amount of heat generated when bone is drilled.[8] However, questions remain about the optimal design of the drill, the best type of irrigation, the degree of heat generated depending on the bone density, and the speed of the drill. Our aim was to find out whether these could now be answered.

Material and methods

We searched the MEDLINE/PubMed database for articles published between January 2000 and February 2014 using different combinations of the keywords implant and; heat or;

* Corresponding author at: Department of Oral and Maxillofacial Surgery, RWTH Aachen University Hospital, Pauwelsstraße 30, 52074 Aachen, Germany. Tel.: +49 241 8080844; fax: +49 241 8082430.
E-mail address: smoehlhenrich@ukaachen.de (S.C. Möhlhenrich).

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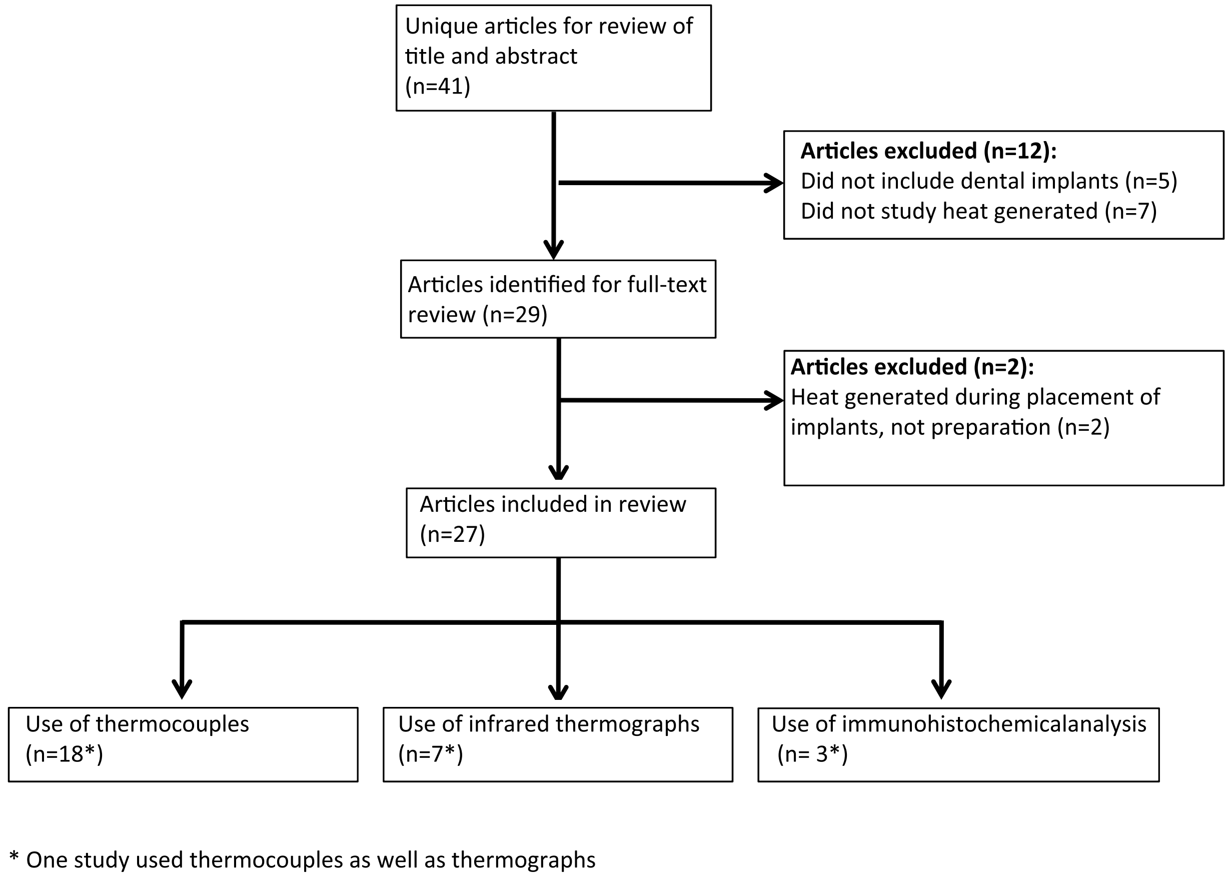

Fig. 1. Search results.

temperature and; osteotomies or; drill. A total of 41 were found. After initial screening of titles and abstracts, the text was studied in more detail. Fourteen articles were excluded because they did not investigate preparation of the implant bed. Finally, 27 studies remained and were included in this review (Fig. 1).

Results

To assess the amount of heat generated in real time, thermocouples were used in 18 studies (Table 1) and infrared thermographs in 7 (Table 2). Three studies investigated immediate cell viability using immunohistochemical analysis (Table 3). Drill wear was the focus of 10 investigations.

Effects of heat on bony regeneration

Depending on the amount of heat generated, bony turnover can be impaired by hyperaemia, necrosis, fibrosis, osteocytic degeneration, and increased osteoclastic activity.[8] Eriksson and Albrektsson investigated the histological effects of heat on bone.[9–11] In animal studies they used a fixed thermal chamber to monitor the metabolism of bone at different temperatures, and they made a distinction between acute and chronic effects. Arterial and venous hyperaemia were observed during acute effects, and blood-flow stopped in different parts of the capillary. There were no connective tissue reactions. A chronic effect was characterised by recirculation of the capillaries after 4 days and was associated with slight elongation of the vessels. Fat cells began to resorb 2 days after the thermal increase and continued to do so for 14 days. They changed in shape and colour then new fat cells were produced. At the third week about 30% of the bone had resorbed. A high temperature for a short duration (50 °C for 1 minute) had almost the same effect as a low temperature for a long duration (47 °C for 5 minutes). A low temperature for a short duration (47 °C for 1 minute) reduced bony resorption by about 10%. The authors concluded that the critical temperature, which can lead to irreversible damage to the bone’s structure, is about 47 °C for one minute. At lower temperatures damage is not anticipated. Therefore, to enable the successful osseointegration of endosseous implants, low temperatures are required during preparation of the recipient site.

Study models

There is no standard study model for investigations into the preparation of implant beds. Different osseous models based on cadaveric bone blocks from cows or pigs were used to