Int. J. Oral Maxillofac. Surg. 2016; 45: 842–850
http://dx.doi.org/10.1016/j.ijom.2016.01.004, available online at http://www.sciencedirect.com

International Journal of Oral & Maxillofacial Surgery

Systematic Review and Meta-Analysis
Dental Implants

Clinical evidence on titanium–zirconium dental implants: a systematic review and meta-analysis

P. Altuna[1], E. Lucas-Taulé[1], J. Gargallo-Albiol[1], O. Figueras-Álvarez[2], F. Hernández-Alfaro[1], J. Nart[3]

[1]Department of Oral and Maxillofacial Surgery, School of Dentistry, Universitat Internacional de Catalunya, Sant Cugat del Vallès, Barcelona, Spain; [2]Department of Restorative Dentistry, School of Dentistry, Universitat Internacional de Catalunya, Sant Cugat del Vallès, Barcelona, Spain; [3]Department of Periodontology, School of Dentistry, Universitat Internacional de Catalunya, Sant Cugat del Vallès, Barcelona, Spain

P. Altuna, E. Lucas-Taulé, J. Gargallo-Albiol, O. Figueras-Álvarez, F. Hernández-Alfaro, J. Nart: Clinical evidence on titanium–zirconium dental implants: a systematic review and meta-analysis. Int. J. Oral Maxillofac. Surg. 2016; 45: 842–850.

Abstract. The use of titanium implants is well documented and they have high survival and success rates. However, when used as reduced-diameter implants, the risk of fracture is increased. Narrow diameter implants (NDIs) of titanium–zirconium (Ti–Zr) alloy have recently been developed (Roxolid; Institut Straumann AG). Ti–Zr alloys (two highly biocompatible materials) demonstrate higher tensile strength than commercially pure titanium. The aim of this systematic review was to summarize the existing clinical evidence on dental NDIs made from Ti–Zr. A systematic literature search was performed using the Medline database to find relevant articles on clinical studies published in the English language up to December 2014. Nine clinical studies using Ti–Zr implants were identified. Overall, 607 patients received 922 implants. The mean marginal bone loss was 0.36 ± 0.06 mm after 1 year and 0.41 ± 0.09 mm after 2 years. The follow-up period ranged from 3 to 36 months. Mean survival and success rates were 98.4% and 97.8% at 1 year after implant placement and 97.7% and 97.3% at 2 years. Narrow diameter Ti–Zr dental implants show survival and success rates comparable to regular diameter titanium implants (>95%) in the short term. Long-term follow-up clinical data are needed to confirm the excellent clinical performance of these implants.

Key words: titanium–zirconium; Roxolid; small diameter; narrow diameter; dental implant.

Accepted for publication 11 January 2016
Available online 3 February 2016

The use of dental implants for the replacement of lost teeth is considered a highly predictable treatment option.[1–7] When the available bone is insufficient to place standard diameter implants, additional surgical techniques for bone regeneration are usually needed.[8–10] An alternative treatment option is to place narrow diameter dental implants (NDIs). Several reports have aimed to define the dimension of a narrow diameter.[11] In this review, an implant with a diameter between 3 and 3.5 mm was considered an NDI. The main indications for the use of NDIs are reduced mesiodistal space,[12] reduced crestal width[13] (narrow

ridge), and reduced amount of interradicular space.[14–17]

There is great concern regarding the resistance and possible fatigue strength of this type of implant, especially when used in areas with a high occlusal load (posterior areas) or in patients with parafunctional habits.[18–24] Since NDIs have a reduced contact area with the bone compared to regular diameter implants, this may also compromise the short- and long-term survival rates.[25,26] For the same reasons, NDIs are not recommended to restore single canines, premolars, and molars.[14] To overcome these problems, titanium alloys with higher tensile and yield strength, such as Ti_6Al_4V, have been used to manufacture NDIs.[27–30] Several studies have reported on corrosion,[31–33] toxicity and biocompatibility issues related to aluminium and vanadium,[31,34,35] and reduced bone responses[35–37] with the use of this alloy.

To further improve the mechanical strength and biocompatibility, a new titanium–zirconium alloy (Ti–Zr) has been developed (Roxolid; Institut Straumann AG, Basel, Switzerland).[38] This material is made of titanium alloyed with 13–15% of zirconium. This metal alloy is highly biocompatible and allows the same surface treatment, sand blasting and acid etching, as commercially pure titanium grade IV.[35] The increased biomechanical properties of this material together with its excellent biocompatibility allow the use of NDIs even in clinically challenging situations. However, clinical evidence regarding the use of Ti–Zr NDIs is still limited. The aim of the present systematic review was to report on the clinical performance of Ti–Zr NDIs in clinical trials.

Materials and methods

Search strategy and eligibility criteria

This systematic review was performed in accordance with the PRISMA statement; the PICO(S) questions were used as evaluation criteria in order to identify the Patient or Population, Intervention, Control and Comparison, Outcome, and Study types.[39]

A literature search was performed to identify available articles reporting on the clinical outcomes of Ti–Zr dental implants. A systematic approach was used to search the National Library of Medicine (Medline via PubMed) for articles published up to December 2014, including the following terms: 'titanium–zirconium' OR 'Ti–Zr' OR 'Roxolid'. The electronic search was supplemented with a manual search of the following publications: *International Journal of Periodontics and Restorative Dentistry*, *International Journal of Oral and Maxillofacial Implants*, *Journal of Periodontology*, *Implant Dentistry*, *Dentistry Today*, *Journal of Oral Implantology*, *Quintessence International*, *International Journal of Oral and Maxillofacial Surgery*, *Clinical Oral Implants Research*, and *Journal of Clinical Periodontology* (Fig. 1).

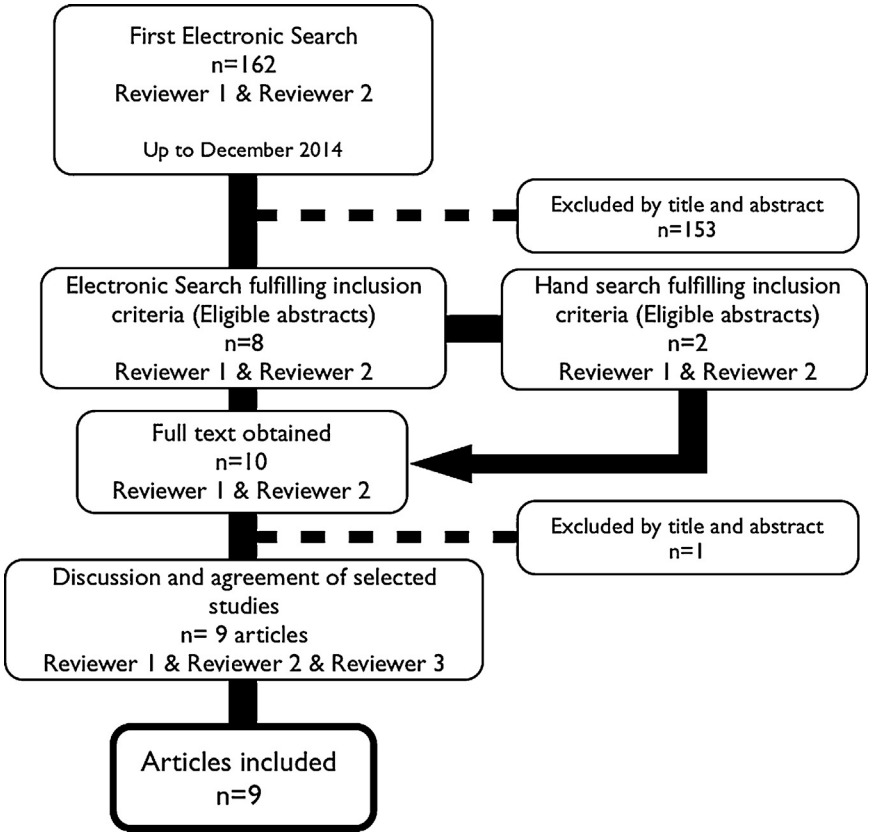

Fig. 1. Flow diagram describing the search strategy.

The search resulted in a total of 162 hits from which eight abstracts were considered potentially relevant, while the manual search yielded two additional abstracts. Two reviewers (PA, EL) independently evaluated the abstracts against the inclusion and exclusion criteria, and the full-text articles were obtained. A third reviewer (JN) was consulted to confirm the eligibility of the selected articles.

Clinical (human) studies on Ti–Zr dental implants that fulfilled the following inclusion criteria were selected: (1) clinical studies of at least 10 treated patients; (2) prospective studies including randomized-controlled and non-randomized controlled studies and cohort studies; (3) retrospective studies including controlled studies, case–control studies, and single cohort studies; (4) a mean follow-up period of at least 6 months; (5) inclusion of data on the survival rate of the implants. The following exclusion criteria were applied: (1) articles written in languages other than English; (2) review articles; (3) studies with fewer than 10 patients, or case reports; (4) a mean follow-up period of less than 6 months. The level of agreement between reviewers regarding study inclusion was calculated using the kappa value.

Data extraction

Full text data extraction was performed independently for each eligible article by at least two reviewers (PA, EL). The following variables were extracted from each study: author(s), year of publication, study design, total number of patients, inclusion and exclusion criteria, follow-up duration, study outcomes (survival and success rates, marginal bone loss (MBL), and peri-implant measurements), patient demographics, implant type and manufacturer, total number of implants placed and number of implants in each patient, failed implants, jaw segment, bone regeneration needs, prosthetic complications, and loading protocols.

The methodological quality of the studies included was evaluated by one reviewer (PA) with regard to study design,