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CASE REPORT

True anatomical zirconia implants for molar replacement: a case report from an ongoing clinical study with a 2-year follow-up

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Abstract

This article describes a case report of an ongoing clinical investigation with modified root-analogue zirconia dental implants. We present a 40-year-old female patient with root caries and chronic apical periodontitis after an unsuccessful root canal treatment. The tooth was carefully extracted, and the socket was cleaned by means of curettage. The root was modified by application of macro-retentions and micro-retentions, and laser scanned, and an exact replica was milled from a zirconia block. Five days after extraction, a one-piece zirconia implant was placed into the extraction socket by gentle tapping with a hammer and a mallet. The soft tissue healed unremarkably around the implant within 3 days. The definitive restoration with a composite crown was performed 3 months after extraction. At 2-year follow-up, the patient presented with an excellent aesthetic and functional result.

Clinical relevance

Dental implants constitute a well-established approach for replacement of lost teeth. However, neither the form nor material of such implants has changed much over the past 40 years. Today, there is scientific evidence that zirconia dental implants osseointegrate well. In addition, our group has previously reported on the successful use of root-analogue implants. This article is a case report of an ongoing clinical trial where both features are combined: the use of zirconia dental implants, which are replicas of the extracted tooth and therefore truly anatomical.

Introduction

Replacement of lost teeth using oral implants is an accepted treatment modality with well-documented high long-term success rates of up to between 90% and 100% at 10-year follow-up[1]. The time span between tooth extraction and implant insertion has become shorter over time. Originally, a healing period of 6–9 months had been recommended before implant insertion (late implant placement). Later on, an earlier placement of implants already after 2–3 months has been proposed (delayed implant placement), and more recently, even immediate implantation within a few days of tooth extraction has been performed clinically, however, in highly selected cases only[2]. Results with shorter intervals between extraction and implantation are comparable to late implant placement. The major advantage of immediate implant placement is the decrease in the treatment time for the patient and reduction in the number of surgical interventions, leading to an improved quality of life and overall cost reduction. Furthermore, alveolar bone resorption and soft tissue regression is avoided or at least significantly reduced, because of early – albeit limited – functional load.

Commercially, pure titanium has been the material of choice for dental implants and abutments for the past 40 years, primarily because of its well-documented biocompatibility and mechanical properties. The success rate was high; however, there is the disadvantage of black metallic components showing through the mucosa or becoming visible in cases of soft tissue recession. Only recently, tooth-coloured ceramic abutments and implants were developed in order to achieve

optimal mucogingival aesthetics. Especially, zirconia possesses good mechanical properties, such as high flexural strength and hardness, and is capable of withstanding simulated long-term loading[3]. Furthermore, it is highly biocompatible with a capacity for osseous integration comparable to titanium implants and is less prone to plaque accumulation than metal substrates.

Another trait that has hardly changed over the past 40 years is the form of dental implants: rotationally symmetrical screw-type or threaded cylinder-type implants. Minor modifications of the shape have lead to the use of tapered and ovoid implants, which are still far from resembling the natural tooth anatomy. The problem associated with immediate implant placement using these conventional implants is the incongruence with the extraction socket necessitating the use of a barrier membrane and/or bone augmentation to prevent down growth of connective tissue or epithelium in-between the implant and the socket[4].

Hodosh and colleagues were the first to tackle the problem of incongruency by employing a novel approach of custom-made root-analogue implants placed into the extraction socket[5]. By adapting the root to the extraction socket instead of the vice versa approach of adapting the bone to a preformed standardised implant, they could reduce the bone and soft tissue trauma. Experimental studies in monkeys yielded extremely favourable results with clear evidence of osseointegration and clinical stability in 88% and 100% of implants at the end of the experimental period, respectively[6,7]. The ensuing clinical trial resulted in a 100% primary stability at insertion and at 1-month follow-up. Because of the high failure rate of 48% over the short time period of 9 months follow-up, this particular implant system had not been recommended for clinical use[8].

We selected a significantly modified approach by:

1 using a new biomaterial, zirconia, for improved aesthetic results by preventing dark discolourations of the gum and display of titanium roots in case of gum recession, further for its high compressive strength and bending forces, and high electrical resistance;

2 choosing an anatomically oriented design by copying the extracted tooth;

3 employing novel surface technologies by not only adding micro-retentions to the entire root surface but also macro-retentions limited to the interdental space in order to get beyond primary stability and allow for osseointegration beyond the period of 1 month and bone remodelling;

4 reducing the diameter of the implant next to the thin cortical bone to avoid fracture and pressure-induced bone loss; and

5 employing a single-stage implantation strategy resulting in immediate – albeit reduced – functional load via the crown stump for prevention of bone resorption because of involution.

Case presentation

A 40-year-old female patient presented with a right maxillar molar with extensive root caries and chronic apical paradontitis after an unsuccessful root canal treatment. Because of the extent of the root caries, it was decided to remove the tooth. After informed consent was obtained, the tooth was carefully extracted under local anaesthesia (Ultracain DS forte, Sanofi-Aventis, Paris, France), avoiding any damage to the hard and soft tissue. The extraction socket (Fig. 1) was cleaned by means of curettage followed by saline irrigation, and an iodoform-soaked cotton gauze was placed in the wound. The extracted root (Figs 2,3) was modified by application of macro-retentions, which was strictly limited to the interdental space, and was laser scanned, and an exact replica was milled from a zirconia block. Five days after extraction, the iodoform cotton gauze was removed, the alveolar socket was again curetted and flushed with sterile saline solution, and a one-piece (implant + abutment) zirconia implant with a surface roughened by sandblast was placed into the extraction socket and subsequently gently tapped into place (Fig. 4). Primary stability was achieved as checked by palpation and percussion. The patient received postoperative analgesics (Parkemed 500 mg, Pfizer, New York, NY, USA) on demand. She was instructed to chew predominantly on the contralateral side and avoid hard food during the healing period of 8 weeks. The soft tissue healed unremarkably around the implant within 3 days. No bleeding on probing or wound infection was observed over the entire follow-up period (Fig. 5). The definitive restoration with a composite crown was performed 3 months after extraction. At 2 years follow-up, the patient presented with a stable implant, unchanged peri-implant marginal bone level and no signs of marginal or apical implantitis as monitored by radiographs and soft tissue parameters, and no bleeding on probing (Figs 6–8). The patient was satisfied with both an excellent functional and aesthetic result.

Discussion

To our knowledge, the present report describes the first successful immediate replacement of a three-rooted tooth with an individualised three-rooted zirconia implant. The proof of the herein described concept applied for replacement of a single-rooted tooth was

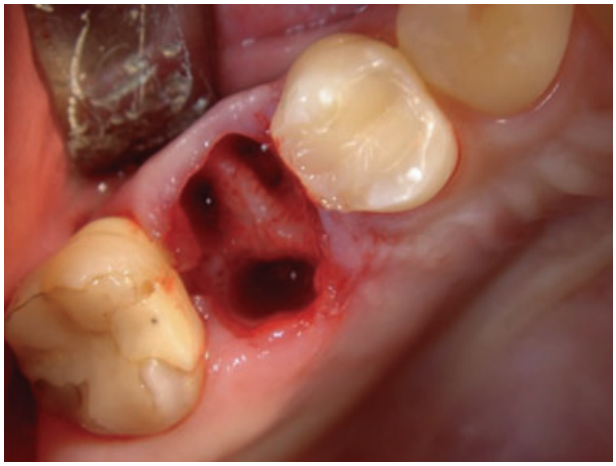

Figure 1 Occlusal view of extraction socket.

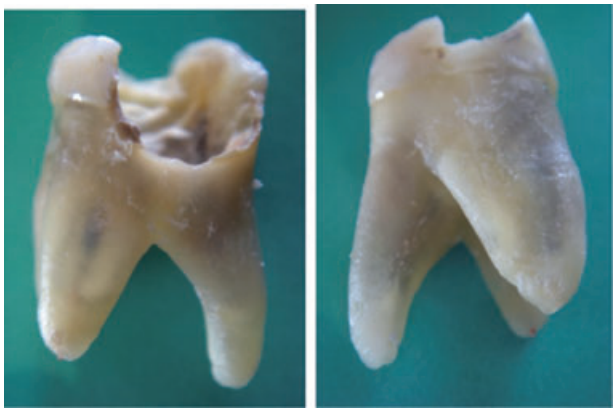

Figure 2 Extracted tooth.

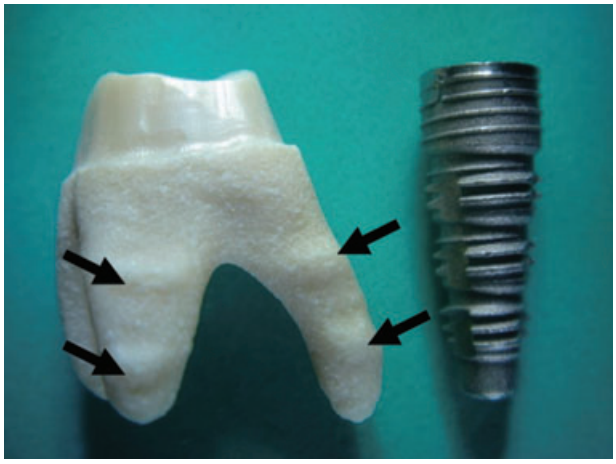

Figure 3 Anatomical zirconia implant compared with conventional titan implant.

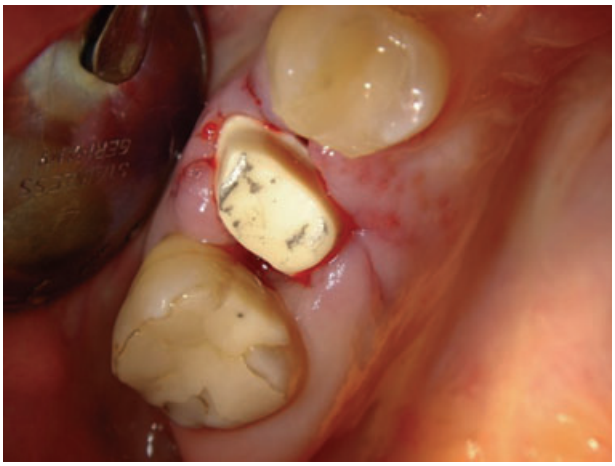

Figure 4 Implant *in situ* immediately after placement by tapping.

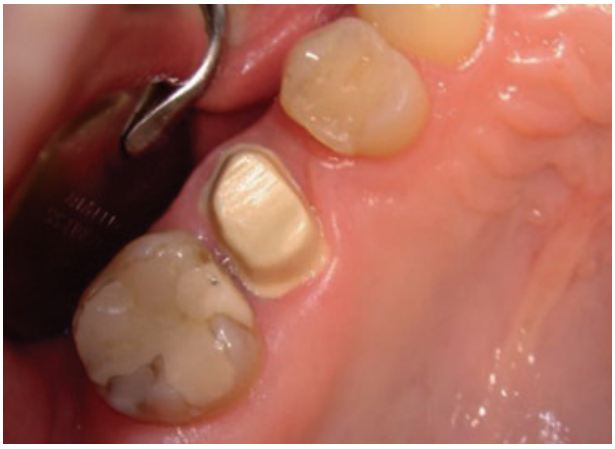

Figure 5 Three months post-implantation prior to crown cementation.

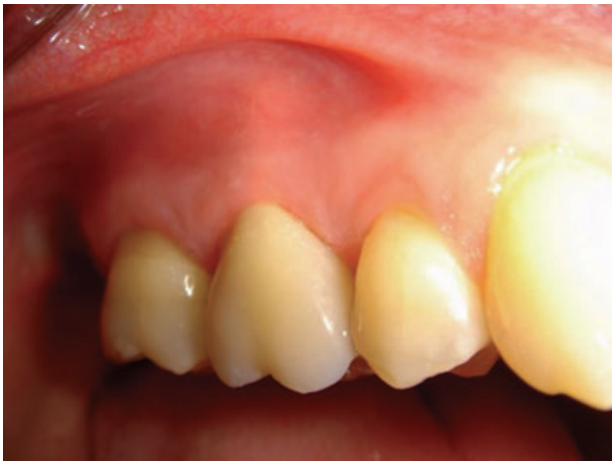

Figure 6 Lateral view of definitive restoration at 2-year follow-up.

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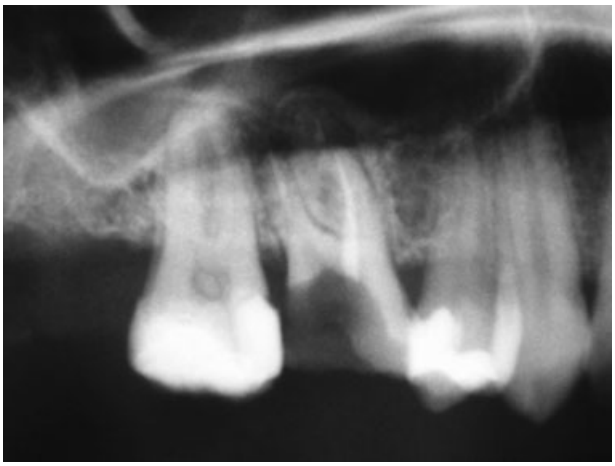

Figure 7 Radiograph at presentation.

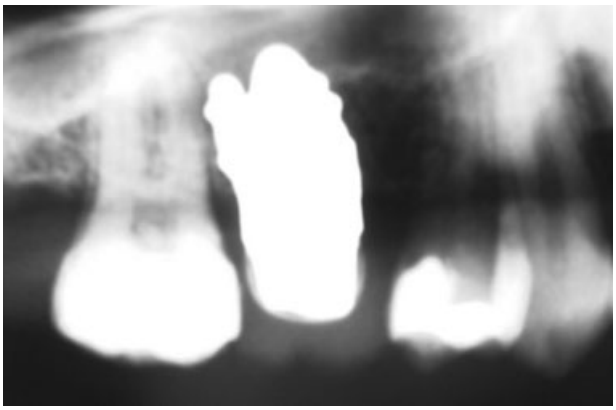

Figure 8 Radiograph at 2 years post-treatment.

published by our group in 2008[9,10]. The concept of replacing teeth with custom-made root-analogue implants was reported as early as 1969; however, the autopolymerised and heat-processed polymethacrylate utilised to fabricate the tooth analogue was encapsulated by soft tissue rather than osseointegrated[5]. Lundgren and colleagues reintroduced the idea of root-analogue implants in 1992[6]. Instead of using polymers, titanium was utilised in an experimental model of immediate implant placement, leading to bony integration in 88%. A good fit between implant and the host bed has been described as an important factor for implant success[11,12]. For that reason, Kohal *et al*. further refined the approach of root-analogue titanium implants by widening the coronal aspect of the implant to compensate for the lost periodontium and to obtain a good congruence between implant and extraction socket. In several instances, the implant insertion led to fractures of the thin buccal wall of the alveolar bone. An ensuing clinical study performed by the same group described an excellent primary stability of root-analogue titanium implants sustained up to 1 month, with a highly disappointing failure rate of 48% at 9 months follow-up. A perfect fit of the implant without any retentions leads to an excellent primary stability; however, at the same time, it might be responsible for the intermediate term failure, because of the subsequent uniform pressure-induced resorption concerning the entire alveolar surface simultaneously. A cross-section of the jaws shows that there is only sufficient room for enlargements and retentions in the interdental space, whereas the thin buccal and lingual layers do not allow for any enlargement of implants in this area. For these reasons, we chose a significantly different approach, manufacturing root-analogue implants with macro-retentions in the interdental space, an implant diameter reduction of 0.1–0.5 mm next to the buccal cortical bone. The surface was roughened by sandblast, resulting in enhanced bone integration. Zirconia implants were used in our studies to achieve better aesthetic results and because of the superior biocompatibility and mechanical properties. Zirconia was introduced into dentistry as an ideal replacement for metal, because of its good chemical and dimensional stability, its mechanical and fractural strength, and toughness. Comparison studies between titanium and zirconia ceramic implants that were inserted in the bone of animals indicated that both kinds of implants osseointegrate to the same extent and were well accepted as indicated by the lack of adverse reactions to the implants and the high level of direct bone contact. Brittleness, which has been discussed as a potential disadvantage of zirconia, seems not to play a role in our approach because of the dimensions of truly anatomical dental implants. Not a single notable crack of fracture was observed within 5 years of clinical application of zirconia dental implants in our hands[10,13]. Furthermore, a single-stage implant approach with a crown stump was chosen, because it leads to an early but reduced functional load allowing still for osseointegration because of the maximised implant – bone contact surface while preventing unaesthetic early bone resorption observed with submerged implants. While successful immediate loading protocols with commercially available implant types require a careful and strict patient selection, our novel approach leads to a high degree of primary stability and shorter healing periods, allowing for instant reduced loading of the crown stump without necessitating a protective splint.

The case described in the present article, which is part of a larger ongoing clinical trial, demonstrates that

immediate placement of significantly modified, root-analogue, non-submerged zirconium dioxide implants yields excellent results superior to previously described custom-made root-analogue titanium implants with a uniform shape.

Conclusions

To the authors' knowledge, this case represents the first report on the successful clinical use of an immediate, single-stage, root-analogue zirconia implant for replacement of a three-rooted tooth. Significant modifications such as macro-retentions seem to indicate that primary stability and excellent osseointegration of such implants can be achieved, while preventing unaesthetic bone resorption leading to unaesthetic results. The macro-retentions have to be limited to the interdental space, avoiding fracture of the thin buccal cortex. The herein described technology is a combination of a truly anatomical implant design with the use of a new biomaterial and surface technology including both micro-retentions and macro-retentions. This novel approach is minimally invasive, respects the underlying anatomy, and is time and cost saving with improved aesthetic results, leading to an increased patient acceptance. This successful study warrants further clinical research in well-controlled trials.

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