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Case Report
Implants

Immediate, single stage, truly anatomic zirconia implant in lower molar replacement: A case report with 2.5 years follow-up

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Abstract. This report demonstrates the clinical use of a modified, truly anatomic, root-analogue zirconia implant for immediate replacement of a two-rooted, left first mandibular molar. A 50-year-old female patient with chronic apical periodontitis of the left mandibulary first molar was referred and the tooth was extracted. The mesial root had to be removed surgically due to a root fracture. A truly anatomical, root identical, roughened zirconia implant modified by macro-retentions was manufactured and placed into the extraction socket by tapping 7 days later. After 4 months a composite crown was cemented in place. No complications occurred during the healing period. A good functional and aesthetic result was achieved with minimal bone resorption and soft tissue recession at 30 months follow-up. This report describes the successful clinical use of an immediate, single stage, truly anatomical root-analogue zirconia implant for replacement of a two-rooted tooth. Significant modifications such as macro-retentions yielded primary stability and excellent osseointegration. This novel approach is minimally invasive, respects the underlying anatomy, aids socket prevention, is time- and cost-saving with good patient acceptance as there is no need for bone drilling, sinus lift, bone augmentation or other traumatic procedures.

Keywords: immediate; truly anatomical; two-rooted; single stage; zirconia.

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Replacement of lost teeth using oral implants is an accepted treatment modality with well-documented, long-term success rates of 90–100% at 10-year follow-up. The time between extraction and implant placement varies from a few days (immediate) to several months (late). The main advantages of immediate implant placement are the decrease in treatment time and the reduction in the number of surgical interventions leading to improved quality of life for the patient and overall cost reduction. Irreversible alveolar bone resorption and soft tissue regression are avoided or significantly reduced, owing to early, albeit limited, functional load.

Over the past 40 years, screw- or cylinder-type implants have been used in most

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instances with no changes of the principle and only slight changes in design. The problem associated with immediate placement of these conventional implants is their 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.

The problem of incongruency was tackled by the use of custom-made root-analogue implants. The root was adapted to the extraction socket resulting in reduced bone and soft tissue trauma. At insertion and 1 month follow-up, a 100% primary stability rate was reported, but the failure rate was almost 100% at 1 year follow-up.

The authors selected root identical implants with significant modifications. These included the use of zirconia for its excellent biocompatibility, diminished plaque accumulation, improved aesthetic results (by preventing dark discoloration of the gum and display of titanium roots in case of gum recession), it has high compressive strength and bending forces, fracture toughness and high electrical resistance. The root surface was modified in two ways, by adding micro-retentions to the entire root surface and limiting macro-retentions to the interdental space. The implant diameter was reduced next to the thin cortical bone to avoid fracture and pressure-induced bone loss. A single stage implantation was used, resulting in immediate, albeit reduced, functional loading via the crown stump for prevention of bone resorption.

Case report

A 50-year-old woman with chronic apical periodontitis of the first mandibulary left molar was referred. The tooth had been treated previously for extensive caries (Fig. 1). After informed consent was obtained the tooth was carefully extracted under local anaesthesia (Ultracain DS Forte, Aventis; Fig. 2). Owing to a fracture, the mesial root had to be removed surgically through a vestibular bone window keeping the alveolar border completely intact (Fig. 2b). The extraction socket and the area of the apical periodontitis were cleaned by curettage and an iodoform-soaked cotton gauze was placed in the fresh socket. The extraction socket and the vestibular window were closed by sutures (Fig. 2c). The extracted tooth was glued together with the fractured mesial root (Fig. 3a). Macro-retentions, designed according to the study protocol,

Fig. 1. Clinical situation at the patient's fist visit: mandibular second left molar in place.

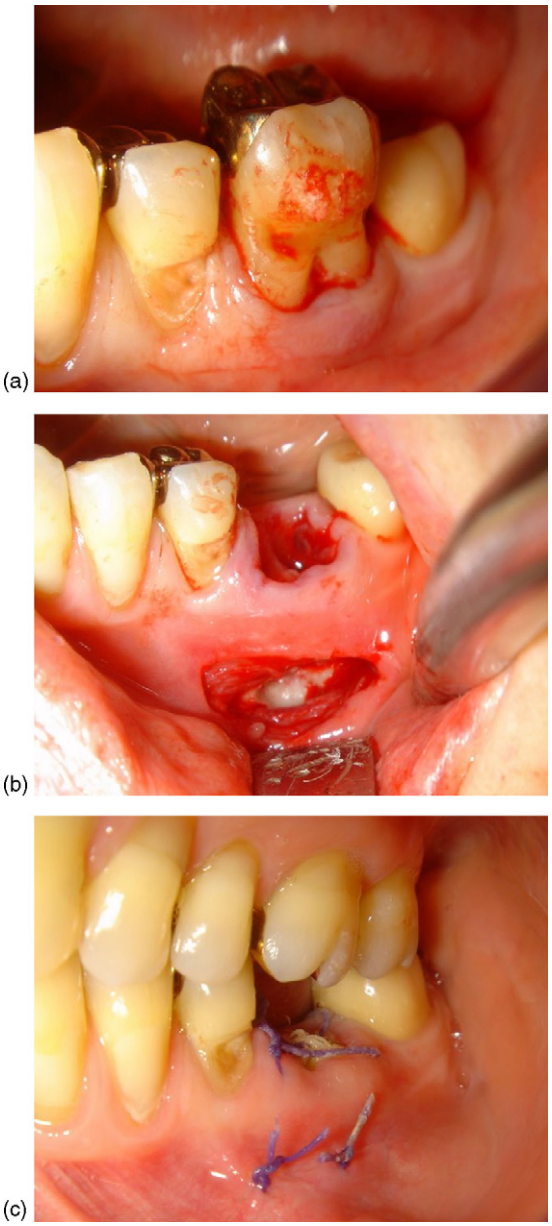

Fig. 2. (a) Tooth extraction. (b) Extraction socket with vestibular window after surgical removal of fractured root. (c) Extraction socket 1 week after tooth removal, prior to implant placement.

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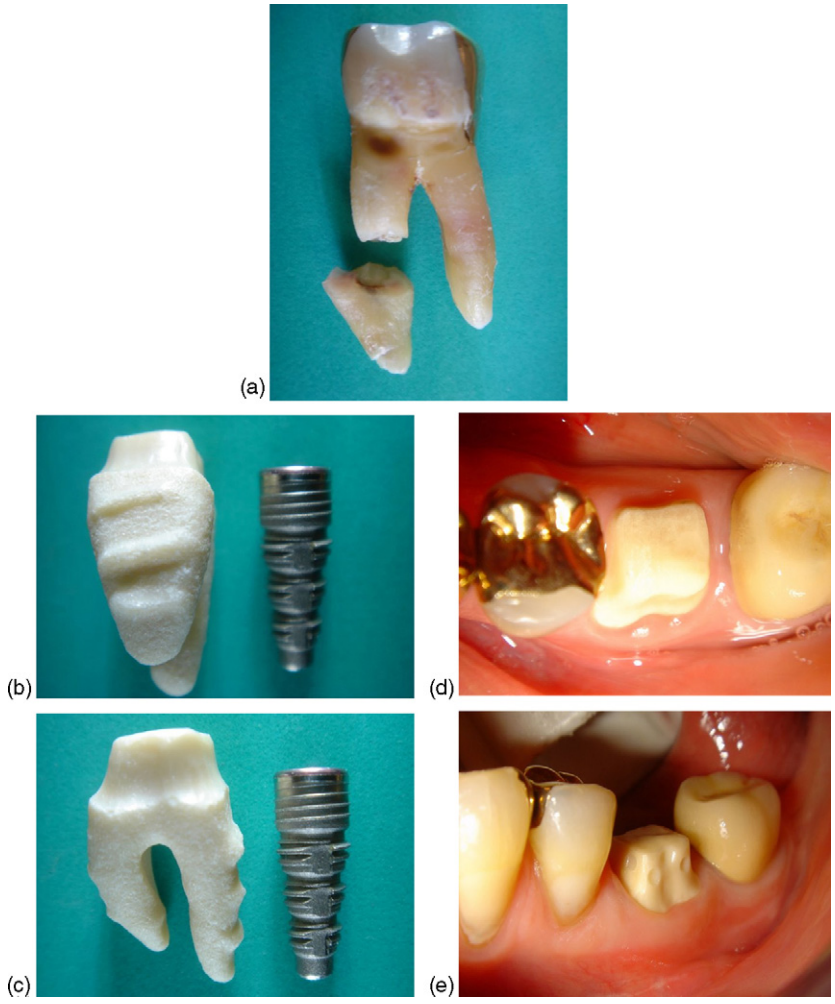

Fig. 3. (a) Extracted tooth with fractured mesial root. (b) Custom-made zirconia implant with the mesial root slightly modified for ease of implant placement compared with a conventional titanium implant (interdental view). (c) Buccal view. (d) Zirconia implant in situ 1 week after placement. (e) Zirconia implant at 4 months, with macro-retentions, prior to cementing on the crown.

were strictly limited to the interdental space. On top of the root a stump was created for later connection to the crown. The modified root was laser scanned and a replica was then milled from a medical-grade zirconia block, the surface roughened by sandblasting and sintered for 8 h (Fig. 3b and c). The implant was cleaned in an ultrasonic bath containing 96% ethanol for 10 min, packaged and steam sterilized. On day 7 the sutures and the iodoform cotton gauze were removed, the alveolar socket was again curetted and flushed with sterile physiological saline solution. The custom-made individualized implant was placed into the socket under finger pressure and subsequent gentle tapping with a hammer and a mallet. Primary stability was achieved as checked by palpation and percussion. The patient was instructed to chew predominantly on the contralateral side and avoid hard food on the implant side for 8 weeks.

At the control visits, 3 and 10 days post-implantation, no postoperative pain, swelling, or bruising was reported (Fig. 3d). Over the entire follow-up period a clinically healthy marginal area was present with no bleeding on probing or wound infection. Owing to the surgical intervention during tooth extraction for the removal of the fractured root it was decided to wait for 4 months before the definitive prosthetic restoration was performed (Fig. 3e). At 24 months follow-up, the patient presented with a stable implant, unchanged peri-implant marginal bone level and complete apical peri-implant ossification with no signs of peri-implantitis as monitored by radiographs and soft tissue parameters and no bleeding on probing (Fig. 4).

Discussion

The present report describes the successful immediate replacement of a two-rooted tooth with an individualized two-rooted zirconia implant. Significant modifications, including macro-retentions limited to the interdental space and diameter reduction next to the thin cortical bone proved crucial in achieving osseointegration and stable implantation in the immediate zirconia replacement of single rooted teeth[8,9].

The concept of replacing teeth with custom-made root-analogue implants is not new. In 1969 the use of a tooth replica implant was reported, however the autopolymerized and heat processed polymethacrylate utilized to fabricate the tooth analogue was encapsulated by soft tissue rather than osseointegrated[3]. Placement of dental implants has become an everyday treatment option for dental patients missing teeth. All implant systems used clinically involve screw-type threaded implants or cylindrical implants with no resemblance to the native root. Lundgren et al. reintroduced the idea of root-analogue implants in 1992[7]. Instead of using polymers, titanium was utilized in an experimental model for immediate implant placement, leading to bony integration in 88%. A good fit between the implant and the host bed has been described as an important factor for implant success. For that reason, Kohal et al. applied a refined approach to root-analogue titanium implants by widening the coronal aspect of the implant to compensate for the lost periodontium and to obtain good congruence between the implant and the extraction socket[5]. In several instances, implant insertion led to fractures of the thin buccal wall of the alveolar bone. An ensuing clinical study, performed by the same group, described excellent primary stability of the root-analogue titanium implants sustained up to 1 month, with a failure rate of 48% at 9 months, and 97% at 1 year follow-up.

Zirconia, which emerged as an alternative material to titanium for dental implant fabrication, was used in the authors' studies to achieve better aesthetic results, and because of the enhanced mechanical and chemical properties and superior plaque resistance. It has a high flexural strength, is hard, and its biocompatibility as a dental implant that osseointegrates to the same extent as titanium implants has been demonstrated in several animal investigations[1,6]. A rough surface topography expedites the bone integration process, so a

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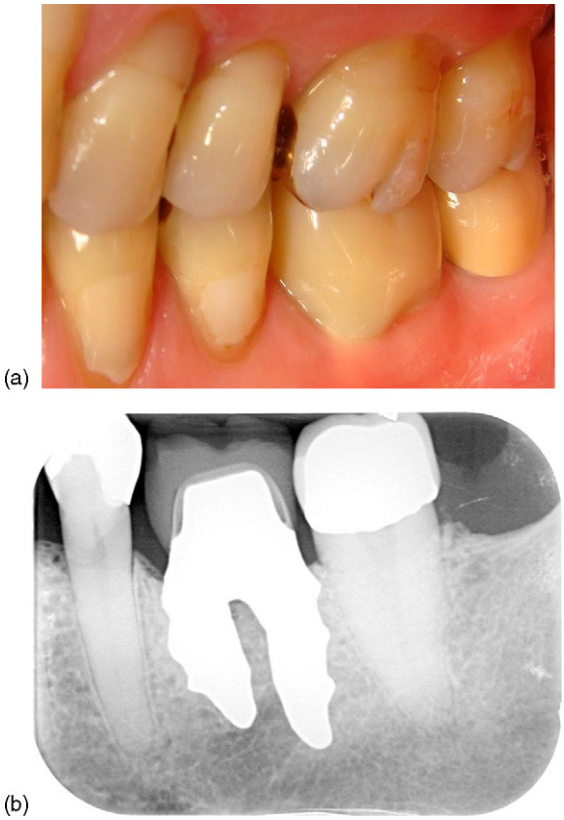

Fig. 4. (a) Two year follow-up with zirconia implant in place with definite prosthetic restoration. (b) X-ray at 2 year follow-up.

root identical replica with a surface roughened by sandblasting was inserted. Kohal et al. tested loaded, rotationally symmetrical sandblasted zirconia implants with metal crowns in the maxillae of 12 monkeys[4]. All implants achieved and maintained stability, and no mechanical problems were reported. In contrast to the results in this experimental study, in a human trial conducted by the authors' group all root identical implants roughened by sandblasting failed, despite being exposed to partial loads. This indicates that a root identical design with microretentions only, does not allow for osseointegration in the clinical situation. A perfect fit of the implant with no retentions leads to excellent primary stability, but it might be responsible for the intermediate term failure, because of the subsequent uniform pressure-induced resorption of the alveolar surface, resulting in a loosened interlock between the implant and bone. This prohibits secondary stability of a conical, root-analogue implant. For that reason, the authors chose a novel approach and published the technical details previously[8]. A cross-section of the jaws shows that there is only sufficient room for enlargements and retentions in the interdental space; the thin buccal and lingual layers do not allow for any enlargement of implants in this area. The authors manufactured root-analogue implants with macro-retentions in the interdental space, an implant diameter reduction of 0.1–0.2 mm next to the thin cortical bone to avoid bone fracture. The surface was roughened by sandblasting to increase the surface area aiding bone cell attachment. A single stage implant approach with a crown stump was chosen leading to an early, albeit reduced, functional load.

There are several advantages to the approach described in the current report. The topography of the implant is similar to the topography of the root of the extracted tooth which eliminates the need for conventional bone drills and other traumatic preparatory procedures for implantation. The introduction of a bifurcation could cause peri-implantitis problems between the roots, an area that is not accessible for hygiene. It can be treated through a hemisection of the implant. All the root-analogue dental implants described in the literature have had high failure rates.

Zirconia is highly biocompatible and has the mechanical properties required to be a useful material for dental implants. The brittleness of zirconia, which is a problem in other applications such as bridges and crowns, is not a major problem in dental root implants because they are broad based, with a diameter well above 3 mm, with the forces applied through the wide crown stump. If microcracks are introduced through grinding they do not affect the survival of the implant. Zirconia implants result in osseointegration comparable with that of titanium[2]. Taking into account the outstanding aesthetic results with zirconia, this new biomaterial could replace titanium, especially in cases of visible dental rehabilitation. The immediate implantation of a root-analogue replica leads to instantaneous support of the soft tissue and limited functional load resulting in perfect socket prevention.

Even though the implants have to be custom-made, the costs do not exceed the expense of a conventional cylindrical implant. Zirconia is an inexpensive material and the production process can be performed by CAD/CAM technology. This novel approach could be an alternative method for replacing teeth immediately after extraction and will raise dental implantology to a new level of truly anatomic implants. The successful clinical study reported here warrants further clinical research in well-controlled trials to evaluate the long-term success rate of root-analogue zirconia implants.

Funding

None.

Competing interests

None declared.

Ethical approval

Not required.

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