CASE REPORT

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Preimplantation filling of tooth socket with β-tricalcium phosphate/polylactic-polyglycolic acid (β-TCP/PLGA) root analogue: clinical and histological analysis in a patient

Klinička i histološka analiza kod pacijenata sa preimplantacijskim popunjavanjem zubne alveole β-trikalcijum fosfatom/polilaktatnom-poliglikolnom kiselinom (β-TCP/PLGA)

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Abstract

Introduction. Bone resorption is a physiological process after tooth extraction. The use of bone substitutes to fill the tooth socket is suggested to prevent bone resorption and establish good bone architecture for implant placement. A pure ß-tricalcium phosphate coated with copolymer (polylactic-polyglycolic acid) as a root analogue, is suitable for filling tooth sockets. **Case report.** We presented a patient successfully treated with root analogue after extraction of the right second lower premolar. Three months later, the patient was planned for the placement of six TE® ITI dental implants into the mandible. During the sugery, the biopsy of bone-like tissue from the previously treated socket was taken. All the implants were immediately loaded due to good primary stability. Histological analysis of the specimen revealed fibrous healing in the area treated with root analogue. **Conclusion.** The use of ß-tricalcium phosphate coated with copolymers after tooth extraction enables satisfactory bone architecture for consequent implant treatment.

Key words:
tooth extraction; bone resorption; therapeutics; oral surgical procedures, preprosthetic; polymers; dental implants; histological techniques.

Apstrakt

Uvod. Resorpcija kosti je fiziološki proces koji nastaje nakon ekstrakcije zuba. Primena koštanih zamenika za popunjavanje alveola nakon ekstrakcije zuba preporučuje se u cilju sprečavanja resorpcije kosti i očuvanja njene arhitekture pre ugradnje dentalnih implantata. Analog korena zuba, sastavljen od β-trikalcijum-fosfata obloženog kopolimerom (polilaktatna poliglikolna kiselina), pogodan je za terapiju ekstrakcione alveole. **Prikaz bolesnika.** Prikazan je pacijent sa uspešnim popunjavanjem ekstrakcione alveole drugog donjoviličnog premolara sa analogom korena zuba. Tri meseca kasnije kod pacijenta je ugrađeno šest ITI TE® implantata u donju vilicu i tom prilikom izvršena je biopsija koštanog tkiva predhodno tretirane alveole. Svi implantati odmah su opterećeni zbog dobre primarne stabilnosti. Histološki nalaz bioptičkog uzorka ukazao je na fibrozno zarastanje u tretiranoj ekstrakcionoj alevoli. **Zaključak.** Upotreba β-trikalcijum-fosfata obloženog kopolimerom za popunjavanje ekstrakcione alveole zuba omogućava postizanje zadovoljavajuće arhitekture kosti za buduću terapiju dentalnim implantatima.

Ključne reči:
zub, ekstrakcija; kost, resorpcija; lečenje; hirurgija, oralna, preprotetske procedure; polimeri; zubi, implantati; histološke tehnike.

Introduction

The major sequel of human tooth loss is the loss of alveolar bone. The rate of this process is highest immediately after tooth extraction – the height of the alveolar process decreases several millimeters (mm) within the first 6 months of the healing period [1]. The unique atrophy of the alveolar process has been described as reduction of residual ridges [2] and considered to be multifactorial in origin [1]. Atrophy of the alveolar ridge may cause aesthetic and surgical problems in prosthetic dentistry, especially when implant treatment is planned.

Immediate alveolar ridge prophylaxis after tooth extraction includes preservation of the alveolar process by retention of endodontically treated roots (physiologically most accepted), immediate implant placement, guided bone regen-

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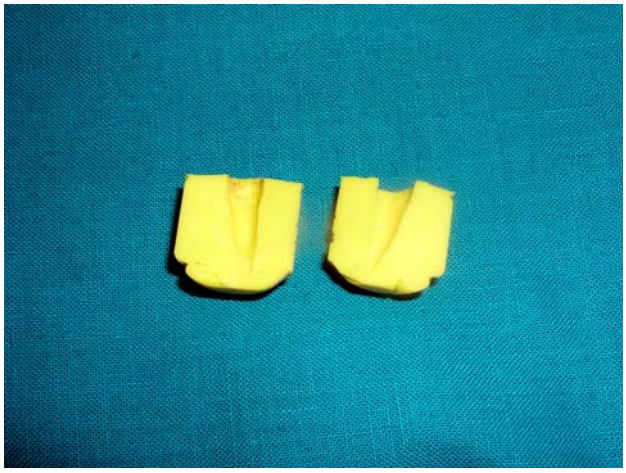
eration and the use of root analogues [3–10]. The use of root analogues as preimplant therapy can provide adequate quantity of bone and soft tissue for implant placement. Many authors showed that different bone substitute materials had been used as root analogues, some of them being: dense hydroxyapatite [5], polyglycolic acid [6], polylactic acid [7], bioabsorbable polylactic-polyglycolic acid (PLGA) [3, 4], deproteinized bovine bone mineral integrated in a 10% collagen matrix [11], β-tricalcium phosphate (β-TCP) combined with type I collagen [8] and β-TCP/PLGA [12]. RootReplica® (Degradable Solutions AG, Switzerland) consists of absorbable β-TCP granules (Ø: 500–800 μm) coated with PLGA layer (about 15 μm). It was developed in order to maintain the dimension of the alveolar process. Using the moulding technique, RootReplica® can be exactly shaped into the form of an extracted tooth root. This scaffold has an interconnected open porosity (55%) and a medium pore diameter of 280 μm. Its degradation occurs without releasing large amounts of acid products [12].

In this paper we described clinical and histological follow-up of implant stability in a patient who had received six immediately loaded titanium implants in the mandible, one of which being inserted in the extraction socket previously treated with biodegradable β-TCP/PLGA root analogue.

Fig. 1 – The tooth 45 removal

a preimplant treatment. The tooth 45 was atraumatically removed three months before the planned implantation and placed in the sterile impression material up to the level of cement-enamel junction as to prepare a polyvinyl siloxane model that exactly reproduces the shape of the root (Figure 2, a and b). The cavity of the mould was filled with β-

a)



b)

Fig. 2 – a) Extracted tooth placed in the sterile impression material; b) the polyvinylsiloxane model

Case report

In November 2004, a healthy 52-year-old female patient with no contraindications to surgical treatment came for prosthetic treatment with dental implants. Clinical and radiographic findings revaled bilateral partially dentate mandible (Kennedy Class I), as well as a vertical root fracture of the tooth 45. After radiographic analysis and producing diagnostic cast, we decided to remove the fractured tooth 45 (Figure 1) and to put six implants bilaterally in the regions of the second lower premolars and first and second lower molars to support a fixed prosthetic reconstruction.

To provide an adequate soft tissue contour and bone dimension for implant placement in the region of the right second premolar that had to be extracted, its socket was filled with root analogue, β-TCP/PLGA (RootReplica®), as TCP/PLGA granules. The mould with the granules was then heated at 80ºC for 2 minutes to fuse the granules together and form a mechanically stable copy of the root (Figure 3, a and b).

RootReplica® was inserted into the bleeding socket with a slight pressure (Figure 4). After filling the extraction socket, computer tomography was performed to provide vertical and horizontal dimensions of the bone in the treated area (Figure 5). The succeeding radiograph, taken three months later, immediately before the placement of the implant, showed an adequate thickness of bone walls to accommodate Ø3.3 mm diameter implants (Figure 6). The tissue in the former tooth socket was apparently firm from the clinical point of view. During implant insertion, a trephine-cylindrical biopsy specimen (using the trephine drill Ø2.0 mm) was processed for light microscopy (Figure 7).


a)

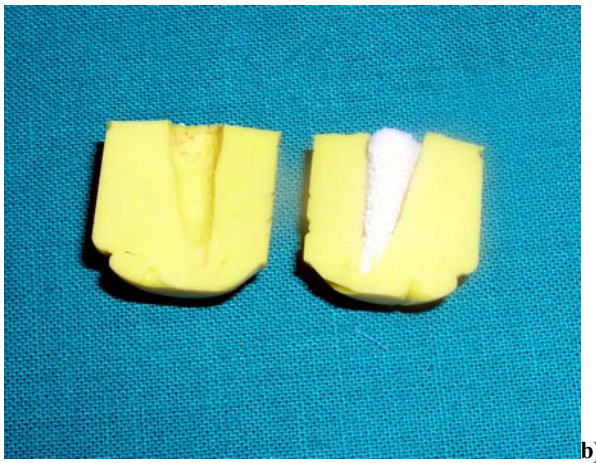

b)

Fig. 3 – a) Heating of the mould; b) β-tricalcium phosphate/polylectic-polyglycolic acid copy of the root

Fig. 4 – Placing of the root replica in the postextraction wound

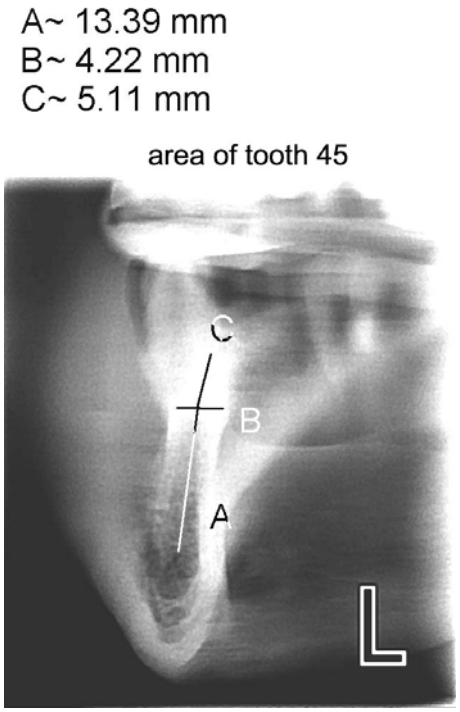


Fig. 6 – Radiograph three months later

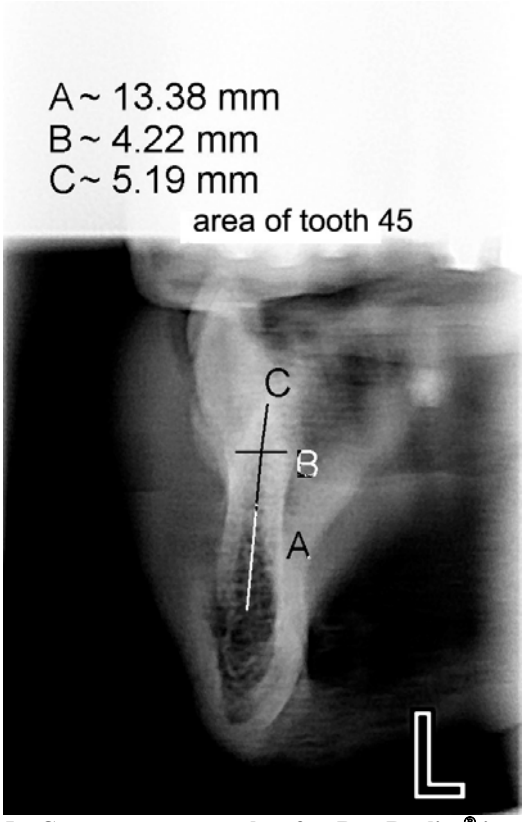


Fig. 5 – Computer tomography after RootReplica® insertion

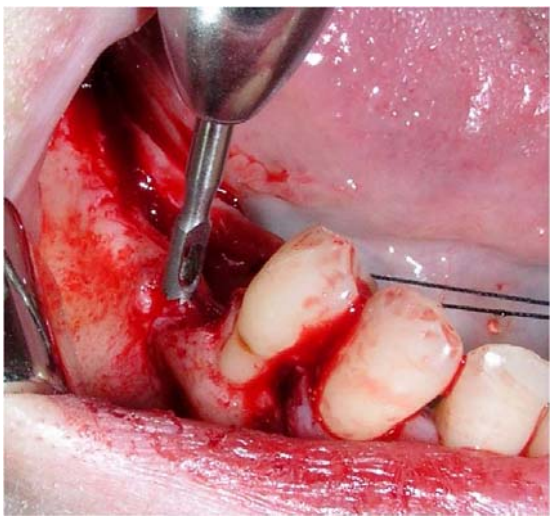


Fig. 7 – Taking of trephine-cylindrical biopsy

Placement of all implants was done using local anesthesia with 2% lidocaine with epinephrine (Xylestesin, ESPE Dental AG, Seefeld, Germany). After flap elevation, implant sites were prepared in accordance with the usual procedure for Straumann TE® implants. Straumann TE® implants (Institute Straumann AG, Waldemburg, Switzerland) of Ø3.3/4.8 mm diameter were used (Figure 8). The flap was

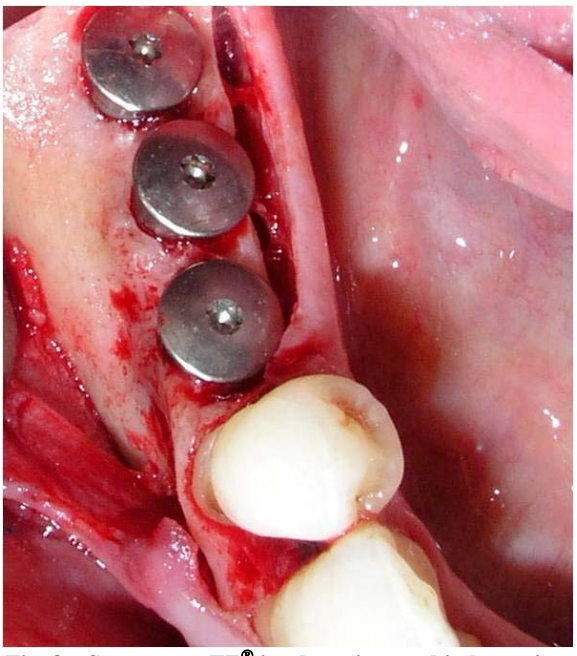


Fig. 8 – Straumann TE® implants inserted in lower jaw

closed with horizontal and single sutures. Resonance frequency analysis (RFA), done with Osstell mentor® (Integration Diagnostics AB, Sävedalen, Sweden), was used to check the primary stability of all the six implants, as well as in the follow-up period (6, 13 and 52 weeks). As all implants fulfilled the criteria for immediate loading [13], they were immediately loaded (on the same day of implant insertion). Therefore, temporary restorations were performed according to the immediate loading protocol. Three months later, the temporary restorations were changed with metal-ceramic bridges as definitive prosthetic reconstructions (Figure 9).

Fig. 9 – Definitive prosthetic reconstruction

The biopsy specimen was immediately immersed in a fixative solution of pH 7.2, containing 2.5% glutaraldehyde and 2.5% paraformaldehyde in the 0.1 mol/L phosphate-buffered saline (PBS). After washing in 0.1 mol/L PBS, the specimen was dehydrated in graded alcohol and processed for embedding in methylmethacrylate. Semithin sections were cut and stained with haematoxylin and eosin for light microscopic examination, magnification being × 40.

No signs of microbial infection, exudation or dehiscence were noted in the healing period of the post-extraction wound treated with RootReplica®. Three months later, soft tissue covered the area treated with β-TCP/PLGA root analogue, forming a nice gingival shape for implant insertion. At the same time point computer tomography showed no loss of bone dimension (Table 1).

RFA presented a successful primary stability of all the inserted implants (Table 2). After six weeks, we noted a decrease of implant stability quotient (ISQ) of the implant inserted in the area filled with β-TCP/PLGA root analogue at the level of –9. At the same time point, a slighter decrease of implant stability was observed for the most of the immediately loaded implants. However, the increase of implant stability was evident lately for all the inserted implants (Table 2).

Table 1

The mandibular bone width measured by computer tomography

Period	Bone width (mm)	Bone height (mm)
At the time of RootReplica® placement	4.22	13.38
At the time of Straumann TE® implantation	4.22	13.39

Table 2

Resonance frequency analysis of implant stability immediately after the implant placement and within a 52-week period

Area of immediately loaded implants	Implant stability quotient			
	Primary stability	6th week	12th week	52nd week
35	80	72	79	80
36	80	71	78	80
37	82	73	77	81
45 (placed in the socket filled with root analogue)	76	67	81	81
46	77	79	80	81
47	81	79	81	81

At the time of tissue specimen taking for biopsy, RootReplica® was stable in the extraction site. Histological examination of the trephine-harvested tissue of the extracted socket treated with RootReplica® showed particles of the implanted material separated by the soft connective tissue, with inflammatory cells present in the area (Figure 10).

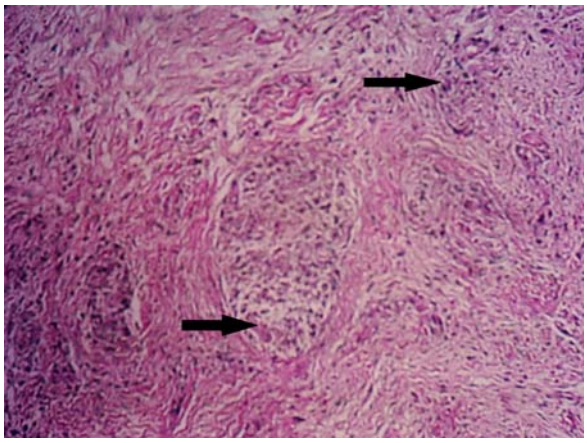


Fig. 10 – Histological view of the trephine-harvested tissue of the extracted socket treated with RootReplica® (haematoxylin and eosin ×40) – arrows point to the inflammatory cells

Discussion

Different treatment modalities have been used to prevent post-extraction atrophy of alveolar ridges and maintain their original diameter and shape. To our knowledge, there have been only a few publications referring to extraction sockets treated with root analogs [3–8]. The presented case report indicates clinical and histological findings of the process of post-extraction alveolar socket healing after the placement of biodegradable β-TCP/PLGA material as a rootcopy before definite implant placement. The final radiographic outcome in this case broadly agrees with previous reports [3, 4]. We noticed similar values of bone height and width after RootReplica® placement into the extraction socket and 3 months later. The patients provided with dense hydroxyapatite root replica implants, after a 1-year follow-up period, were found to have significantly higher and wider residual ridges than non-treated patients [3]. In the experimental study of the use of polyglycolic acid root replica for placement in extraction sockets, a significantly higher bone dimension was noticed than in the control group with empty sockets after a 5-month period [5]. A case report on the preserved ridge height after placement of polylactic acid root replica in the extraction socket, during a 21-month observation period, was also presented [6].

Histological and fine structural investigations in the experimental study confirmed the biocompatibility and absorbability of the scaffolds [12, 14], and that β-TCP/PLGA granules were subjected to complete absorption after 24 months [15]. In the report on two cases of alveolar bone regeneration with porous tricalcium phosphate, Zerbo et al. [9] histologically confirmed resorbability of that grafting material and its replacement by bone without adverse reaction.

In the presented patient, inflammatory cells were noticed in the biopsies taken three months (approximately 12 weeks) after the insertion of a root analogue. Contrary to this, histological findings in the study of Nair and Schug [3] showed no inflammatory and foreign-body giant cells, demonstrating a complete biodegradation of a root-replica material during the period of observation. In the presented patient, we found predominantly fibrous tissue in the specimen of tissue filling the post-extraction socket, which could be due to the procedure used. Namely, the manufacturer emphasizes that RootReplica® need not to be covered after insertion in the extracted socket. In an experimental study [12], the authors covered the treated areas with a flap. We did not cover the RootReplica® material after insertion, and that could be the reason for the presence of inflammatory cells in the specimen. However, this fact did not influence the possibility of titanium implant insertion and the gain of its primary stability; moreover, the shape and diameter of the alveolar ridge in the area was quite satisfactory, enabling sufficient architecture of soft tissue for further successful implant placement.

The presence of inflammatory cells in the socket previously treated with root analogue probably contributed to a slightly greater loss of implant stability estimated by RFA. However, later on, in the postoperative period all implants (including the implant inserted in the socket previously treated with β-TCP/PLGA root analogue), demonstrated a substantial gain of stability, in three implants even better than primarily after the insertion. Therefore, treatment of tooth root sockets with β-TCP/PLGA root analogue to enable better alveolar ridge morphology after tooth extraction seems not to interfere with the possibility of titanium implant insertion.

Conclusion

The use of β-TCP coated with PLGA root analogue after tooth extraction enables satisfactory bone architecture for consequent implant treatment.

Acknowledgments

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