Full-mouth Oral Rehabilitation in a Titanium Allergy Patient Using Zirconium Oxide Dental Implants and Zirconium Oxide Restorations. A Case Report from an Ongoing Clinical Study.

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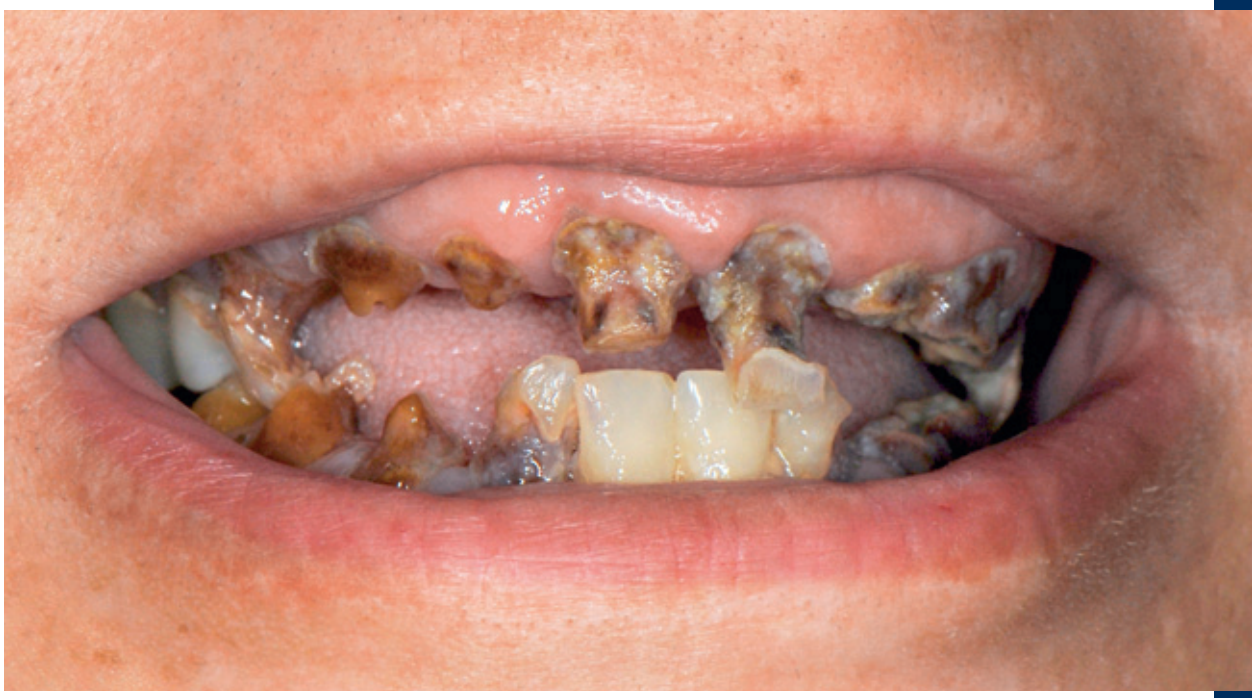

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Abstract

This case report describes the full-mouth oral rehabilitation of a titanium allergic patient. The patient was a young female with amelogenesis imperfecta who had generalized massive tooth destruction.

All teeth in the mouth were extracted and 15 CeraRoot acid-etched (ICE surface®) implants were placed (seven implants in the maxilla and eight implants in the mandible). No immediate temporaries were placed. Temporaries were placed 3 months after surgery, and left in function for 2 months. The case was finally restored with zirconium oxide bridges and ceramic veneering (three bridges in the maxilla and another three in the mandible).

The 3-year follow-up showed good stability of soft tissues and bone level. Zirconium oxide implants and restorations might be an alternative for the oral rehabilitation of titanium allergic patients.

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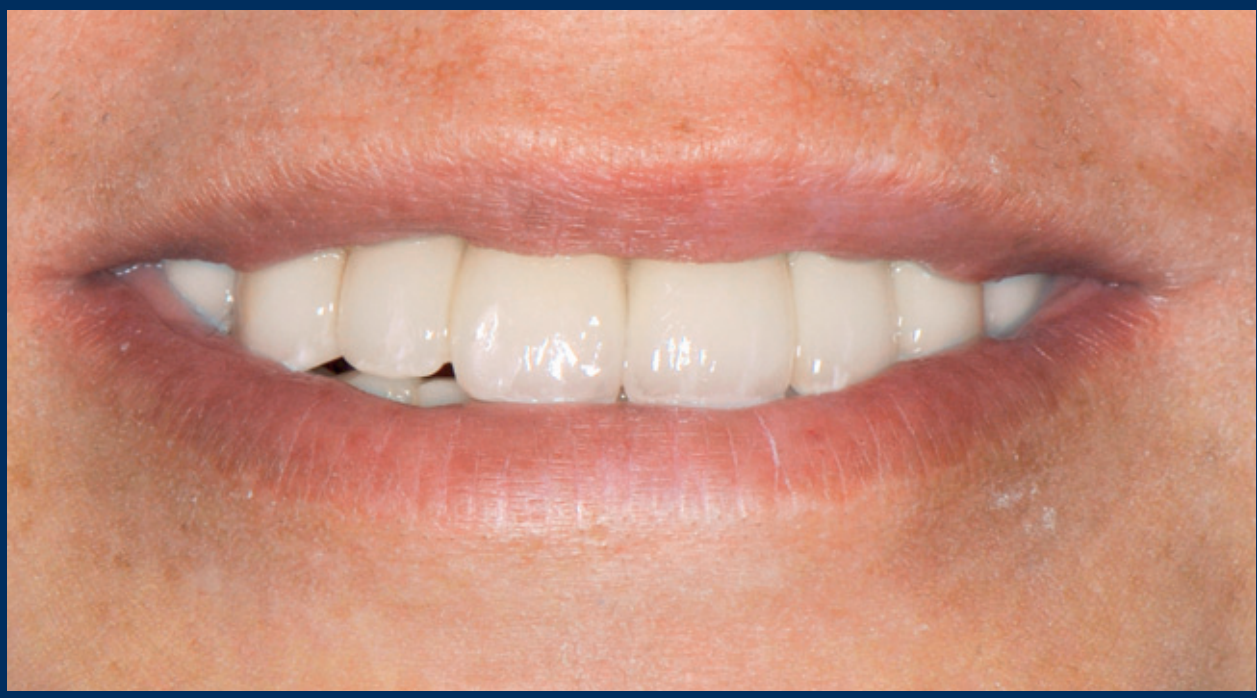


Introduction

The use of titanium (Ti) in medicine and dentistry has increased during the last three decades. Ti alloys have been widely used for dental implants, endoprostheses, pacemakers, stents, orthodontic brackets, and eyeglass frames. The material of choice for dental implants is commercially pure titanium due to its well-documented biocompatibility and suitability for tooling. This biocompatible material[1] has been used for about 30 years as implant substrate and has shown high success rates.[2]

The oxidized Ti implant surface has good corrosion behavior and good biocompatibility and osseointegration properties.[2] Therefore, Ti has been considered to be particularly suitable for use in both dental and prosthetic implantation.

Nevertheless, sporadic cases of Ti intolerance have been reported.[3-11] Skin testing has rarely detected positive reactions to Ti.[3,6,12] Patch testing, which may itself induce sensitization of native T lymphocytes, in general has been validated only for epidermal antigen contact, and is relevant primarily for detecting dermal effects of hypersensitivity (contact dermatitis).[13] On the other hand, *in vitro* testing with the lymphocyte transformation test (LTT) can detect both dermally and non-dermally sensitizing allergens. As an *in vitro* test, LTT cannot sensitize the patient. It has been used successfully to detect hypersensitivity leading to both local and systemic effects.[14-19] In addition, several groups have documented the sensitivity, specificity, reproducibility, and reliability of this approach for detecting metal sensitization, in particular in the optimized version of LTT called memory lymphocyte immunostimulation assay (MELISA®).[20-26] Therefore, MELISA was selected for investigating and diagnosing hypersensitivity to Ti in the present patient.

A possible alternative to titanium might be tooth-colored materials such as ceramics.[27,28] Ceramic materials are highly biocompatible and can be used as dental devices.[29] One ceramic material that has been used in the past as dental implants is aluminium oxide (Al_2O_3).[30-32] This material osseointegrated well but did not have sufficient mechanical properties for long-term loading, and the product was withdrawn from the market.

Recently, another ceramic material with potential for future use as a dental implant material was introduced. Zirconium oxide (ZrO_2), as a metal substitute, possesses good physical properties, like a high flexural strength (900 to 1200 MPa), hardness (1200 Vickers), and Weibull modulus (10 to 12).[33-35] Furthermore, its biocompatibility as a dental implant material has been demonstrated in several animal investigations.[36-43] Also, *in vitro* experiments showed that the material is capable of withstanding simulated long-term load, however the mechanical properties of zirconium seem to be influenced by mechanical preparation of the material.[40,44,45] Moreover, the exposure of zirconium implants to the artificial mouth has not demonstrated statistically significant effects on the mean fracture strength values of the implants.[45] Kohal et al[46] published a case report of a machined zirconium implant and zirconium crown in one patient achieving an excellent esthetic result. Modern

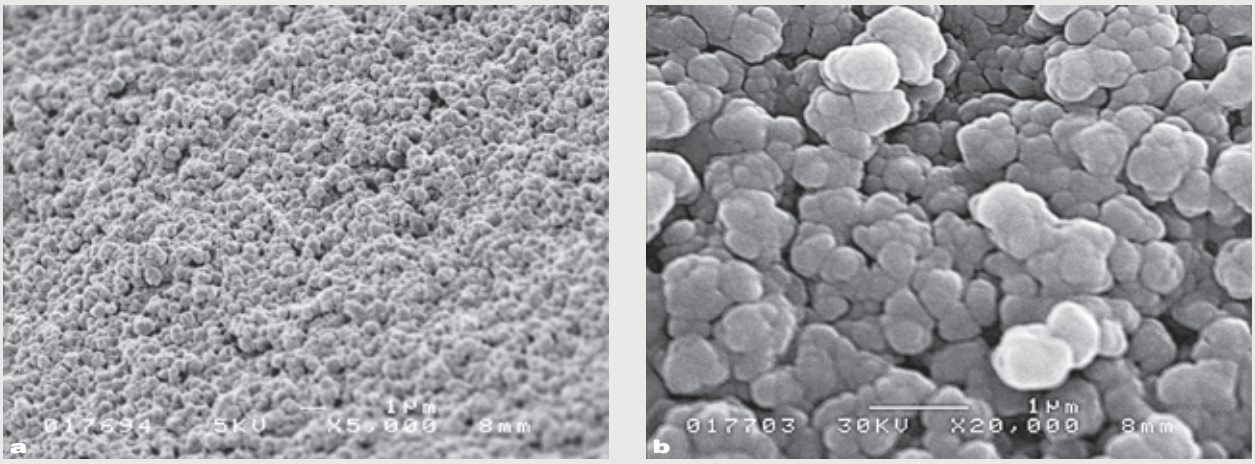


Fig 1 Scanning electron micrographs of CeraRoot with ICE surface. Left: ×5000; right: ×20,000.

implant research shows that a rough surface topography is desirable to enhance the bone integration process,[47] but the turning of zirconium rods results in a relatively smooth surface. Along these lines, Sennerby et al[43] demonstrated a better implant retrieval torque resistance of porous zirconium surfaces in rabbits, and similar results were obtained by Gahlert et al.[48] In a systematic review, Wenz et al[44] concluded that osseointegration of Y-TZP (yttria-stabilized tetragonal zirconia polycrystal) implants might be comparable to that of titanium implants; modifications of surfaces have the potential to improve initial bone healing and resistance to removal torque; low-temperature degradation might affect the behavior of Y-TZP, although it remains under investigation; and long-term clinical trials are needed to evaluate the clinical performance of Y-TZP implants before the implants are used for routine clinical use.

Regarding the long-term performance of Y-TZP-based restorations, there may be major differences between the systems used. Larsson et al[49] reported that some systems might have an unacceptable amount of veneering porcelain fractures.

In a recent publication,[50] the present authors reported the 1-year follow-up preliminary results of an ongoing clinical study with CeraRoot (Oral Iceberg, Barcelona, Spain) zirconium implants, and the success rate was comparable to titanium implants. This ongoing investigation started with two kinds of rough surfaces (one coated and one non-coated), and after the new development of the acid-etched surface (ICE) it was also included in the study. Moreover, the present authors[51] have shown the esthetic potential of this implant system in a highly esthetically demanding case. The present case report is part of the ongoing clinical investigation with the ICE surface (see Figure 1) and is the first publication to report a full-mouth oral rehabilitation with ZrO_2 implants and ZrO_2 restorations.

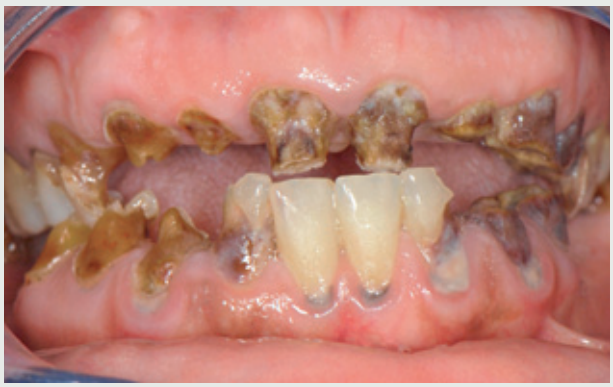


Fig 2 Initial situation: extensive tooth deterioration.

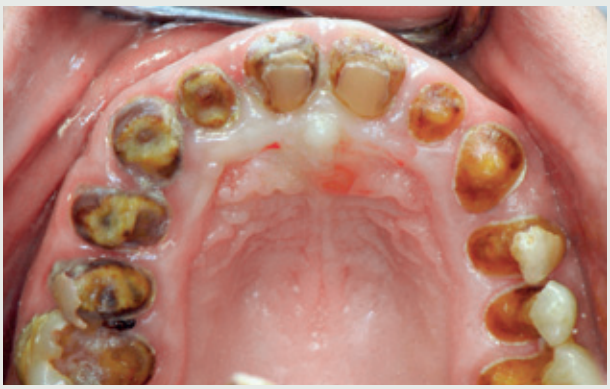


Fig 3 Occlusal view: note the minimal remaining sound coronal tooth structure.

Case presentation

A 38-year-old female with titanium allergy and severe general amelogenesis imperfecta was referred to our office for a full-mouth oral rehabilitation with zirconium oxide implants. The patient reported that her teeth started to deteriorate after her first pregnancy at age 28 and that they had been subsequently neglected as she had been free of pain. Regarding the titanium allergy, the patient presented a history of skin inflammatory reaction, redness, and itching in contact with rings, earrings, eyeglass frames and any prolonged skin–metal contact. For this reason, her dermatologist performed a lymphocyte proliferation test called MELISA (Melisa Medical, Sweden), to get a diagnosis. The tests confirmed her high positive reaction to different metals including titanium (SI = 40). Although there is no clear scientific evidence of allergies with titanium dental implants, the patient's dermatologist advised her not to have titanium dental implants placed nor any other metal restoration due to her history of skin–metal reactions. The patient reported smoking five cigarettes per day and, besides her skin allergy, there was no other relevant medical history.

Initial examination

The initial examination revealed the extensive tooth breakdown (Figs 2 and 3); generalized dental plaque and gingivitis; no periodontal pockets in any site of the mouth (≤3 mm of probing depth); and absence of teeth 46, 47, 35, 36, and 37. The remaining structure of the maxillary and mandibular incisors suggested that her dentition would have an optimal overjet and overbite, and the dental midline was centered with the face and lips. There was a loss of occlusal vertical dimension due to the extensive tooth breakdown. The patient had a gummy smile (Fig 4). The panoramic radiograph (Fig 5) confirmed the extensive tooth destruction and the preservation of the alveolar ridge, except for a moderate resorption in the areas with absent teeth. A chronic periapical

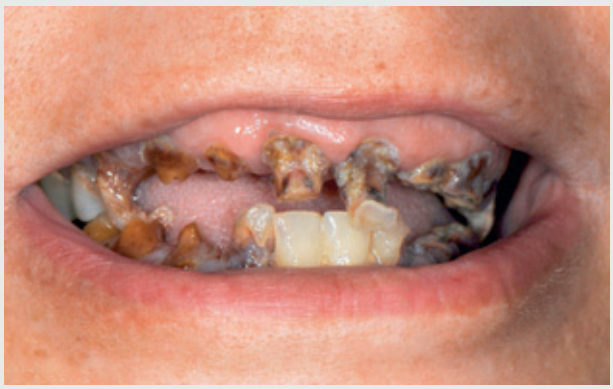


Fig 4 Smile at the initial situation. Note the gummy smile.

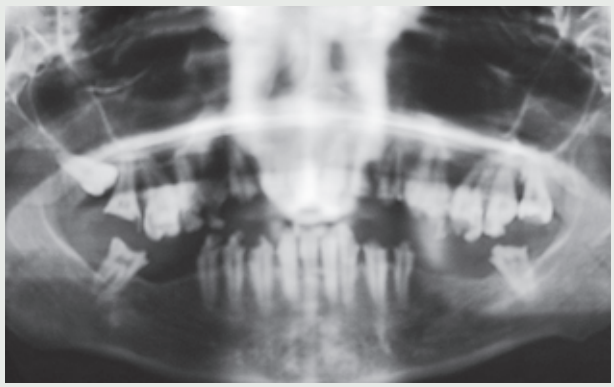
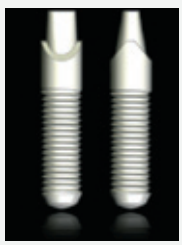


Fig 5 Panoramic radiograph of the initial situation.

Table 1 CeraRoot implant types and indications.

CeraRoot 14	CeraRoot 12	CeraRoot 11	CeraRoot 21	CeraRoot 16
				
For premolars	For mandibular and maxillary lateral incisors	For maxillary central incisors and canines	For small maxillary central incisors and canines	For molars

lesion and fistula was detected in canine 13. At this point, all of the dentition was considered to be non-restorable. Alginate impressions were made, and centric relation records and a face-bow registration were taken to mount study casts in the articulator.

Treatment plan

The preoperative planning was conducted with a diagnostic waxup to have an idea of the treatment objective. This model was then duplicated to fabricate vacuum surgical stents that would serve as a reference during surgery.

All teeth were to be extracted, and implants placed in order to support a fixed oral rehabilitation. ZrO_2 implants (CeraRoot system, see Table 1) and restorations were to be used. These are one-piece implants with five different shapes depending on the tooth to be restored. The plan was to extract all teeth of the maxilla and immediately place the im-

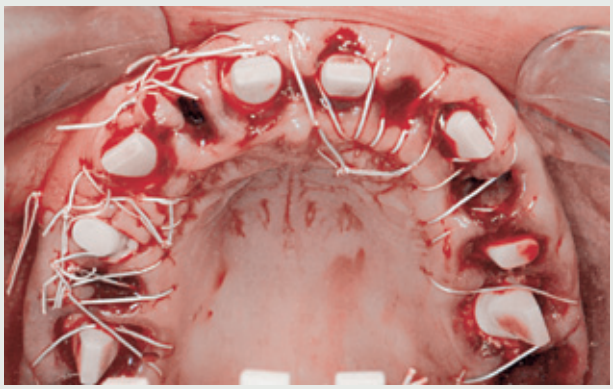


Fig 6 Occlusal view after the maxilla surgery.

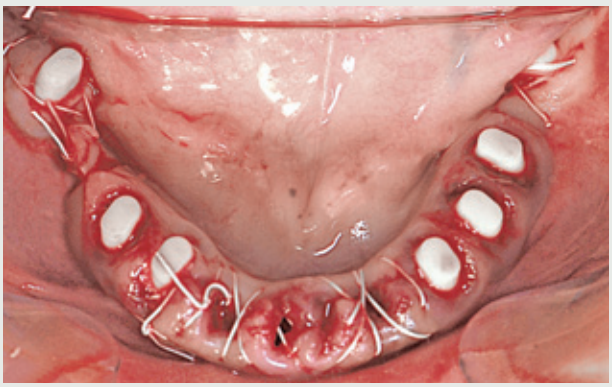


Fig 7 Occlusal view of the mandible surgery.

plants, and 15 days later proceed with the mandible. No immediate provisional restorations were planned in this case because there is no available scientific evidence and no long-term results of full-mouth oral rehabilitations with ZrO_2 implants and immediate function. It was estimated that the healing phase could be around 3 months for optimal implant integration and soft tissue stability.[52] Moreover, the authors did not feel safe placing provisional restorations for a long period with temporary cementation, and having to deal with decementations and possible implant failures. In complex cases, treatment safety is the first priority. The risk of prematurely overloading the ZrO_2 implant abutments was addressed and the authors considered it much lower than immediate temporary restorations.

Temporary bridges were planned for a later stage (3 months post-surgery), after soft tissue healing and implant osseointegration had occurred.

Surgery

Minimally invasive surgery was planned with immediate flapless implant placement into the extraction sites wherever possible, except for the area of maxillary right canine where an apical cyst was present, and in the edentulous areas of the posterior mandible. These latter areas were treated with a conventional flap approach. Since the old occlusion of the patient was an incisal Class I, and midline was correct, the implants were placed exactly in the same position and inclination of the natural dentition (Figs 6 and 7). However, in the anterior maxilla, the drill preparation was done slightly in the palatal wall of the alveolar socket to engage more palatal bone and avoid implant fenestration in the apical region.

The surgery was started in the maxilla. The central and lateral incisors were extracted and two 12 mm CeraRoot 11 implants (thread diameter 4.8 to 6 mm) were placed. The implant sites were carefully prepared and the surgical stents were used to verify correct implant positioning. In the anterior region, it is particularly important that these im-

plants are oriented to the incisal edge in order to facilitate restoration with an optimal esthetic result. Next, the canines were extracted and another CeraRoot 11 implant was placed in the area of tooth 23. The periapical lesion and fistula of canine 13 had resorbed the apical third of the buccal cortical plate. For this reason, a trapezoidal flap was raised in this area. The apical cyst was carefully debrided and irrigated with saline solution. A CeraRoot 11 implant was placed and then a bone graft was performed. Autogenous bone from the drilling sites was placed immediately on the surface of the implant. A second layer of Bio-Oss® (Geistlich, Wolhusen, Switzerland) was placed on top of the autogenous bone. Then a Bio-Gide® (Geistlich) membrane was placed on top and the flap was closed with Gore-Tex sutures (W L Gore & Associates, Flagstaff, AZ, USA). Next, the maxillary premolars and molars were extracted. CeraRoot 14 implants (thread diameter 3.5 to 4.8 mm) were placed in the areas of teeth 14, 15, and 24. Two CeraRoot 11 implants were placed in the areas of teeth 16 and 26, where a Summer's osteotome sinus elevation with bone graft (Bio-Oss) was performed.

At the end of the surgical intervention, the soft tissues around implants and extraction sockets were very mobile, and for this reason sutures were placed across the alveolar ridge to stabilize the soft tissues, especially around implants.

The patient was asked to be on a soft diet for 2 months to minimize loading on the implants. The potential risk of implant failure upon premature loading was discussed clearly with the patient and she expressed her full commitment to the treatment and postoperative regime.

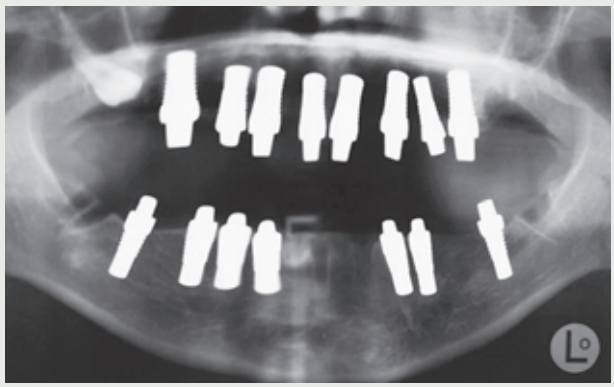


Fig 8 Postoperative panoramic radiograph.

The patient was advised to quit smoking for 15 days before and after surgery. The postoperative panoramic radiograph revealed good positioning of the implants (Fig 8).

The patient was seen 15 days later for the mandibular surgery. Extractions were performed without raising any flaps and immediate implants (CeraRoot 14) were placed in the extraction sockets of teeth 45, 44, 43, 33, and 34 (Fig 7). Sutures were placed to close the extraction sockets in the incisal region. The implants in the areas of teeth 47 and 37 were placed after raising a trapezoidal flap from the first- to third-molar area. Sutures were placed to close the wound. Postoperative instructions that were identical to those following the maxilla surgery were given to the patient.

Healing period

During the healing period, the patient was asked to maintain regular hygiene after meals with a soft surgical toothbrush.

Fifteen days after surgery, the sutures in the mandible were removed. Three weeks after surgery the clinical aspect of the soft tissues was very satisfactory. Two months after surgery the soft tissue was healed (Fig 9). The implants were evaluated and there was no pain on percussion or mobility detected.

Temporary restoration

Two months after surgery, some implants presented with soft tissue lying on the shoulder of the implants. This soft tissue was removed with the aid of an electroscalpel, and impressions were taken directly with a polyether (Impregum™, 3M ESPE, Neuss, Germany) and without any implant preparation. A full-mouth waxup was made (Fig 10), and with this a silicon index. The silicon index was filled with a dual cured resin-based material (Protemp™ Garant, 3M ESPE) and adapted to the maxilla and mandible. The temporary restoration was then polished and cemented on to the implants with GC Temp cement to (GC America Alsip, IL, USA) (Fig 11).

The patient was allowed to adapt to the new occlusion and vertical dimension whilst special attention was given to verify stability of the occlusal scheme, as well as to the esthetics and phonetics over time. With this in mind, the patient's occlusion was evaluated every week for 1 month. Minor adjustments of the occlusion and esthetics were made as necessary in order to establish a good template for the final restorations.

Final reconstruction

The final impressions were taken directly with a polyether (Impregum) without the need for any implant abutment preparation or retraction cords. The temporary restoration served as a guide for designing the final zirconia bridges (CeraCrown, Oral Iceberg), which were finally characterized with a ceramic layering technique (IPS e-max, Ivoclar Vivadent, Schaan, Liechtenstein). The six bridges were cemented with resin-reinforced glass-ionomer cement (FujiCEM, GC America). The case was finalized with anterior incisal guidance and a cuspid lateral guidance (Fig 12).

Follow-up

Three years after final cementation, the ZrO_2 implants and bridges were stable and the patient expressed her satisfaction (Fig 13). The panoramic radiograph (Fig 14) shows the accuracy of the marginal fit of the restoration and the stability of bone level around the implant. The gummy smile (Fig 15) and the lip support were improved (Fig 16).

Discussion

Titanium dental implants are today the gold standard for oral rehabilitations. Nevertheless, for patients suspected of metal hypersensitivity, diagnosis of metal allergies with the LTT should be considered. This test has proven to be the best way to diagnose skin and systemic Ti allergies, although its relation to Ti dental implants has not been scientifically demonstrated.

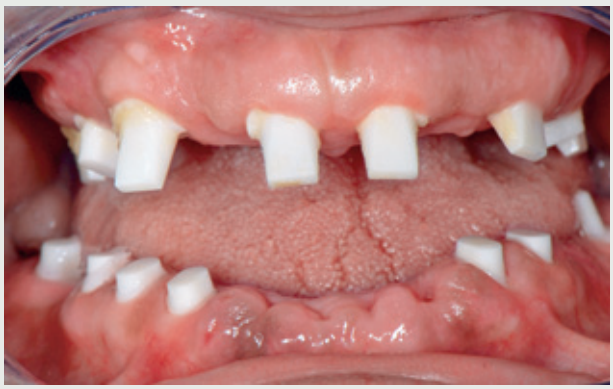


Fig 9 Soft tissue aspect 2 months after surgery.

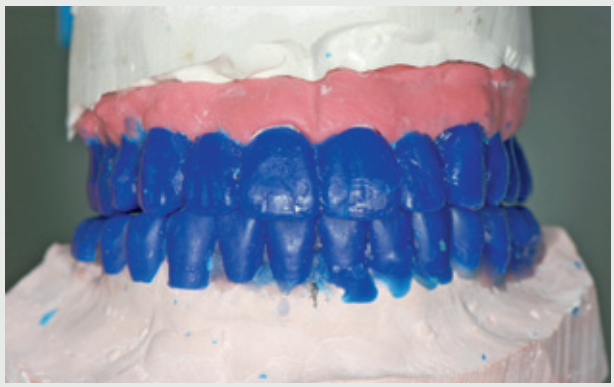


Fig 10 Waxup of the temporary rehabilitation.

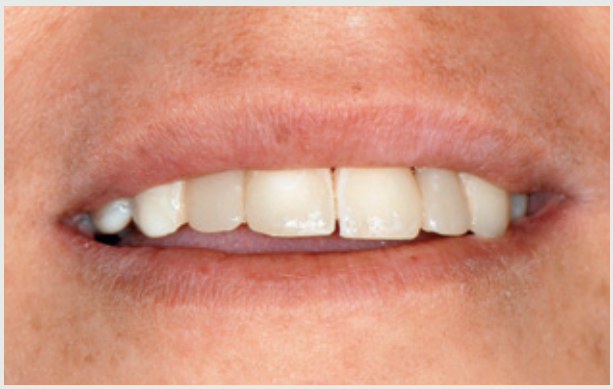


Fig 11 Resin temporaries in place 3 months after surgery.

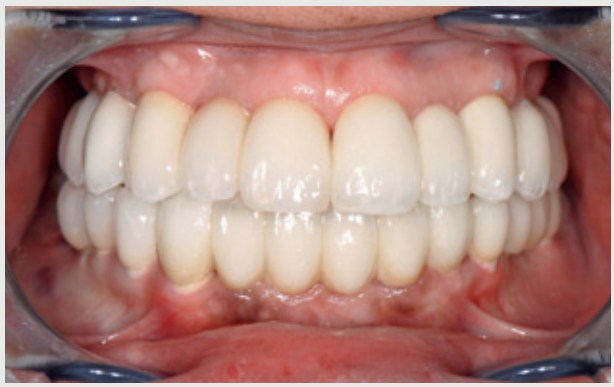


Fig 12 Cementation of the ZrO_2 bridges.

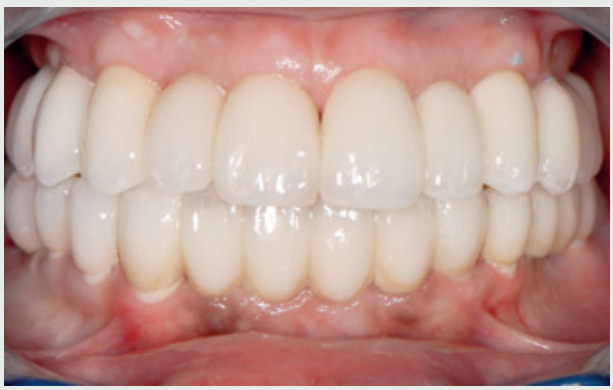


Fig 13 Note the stability of soft tissues at the 3-year follow-up.

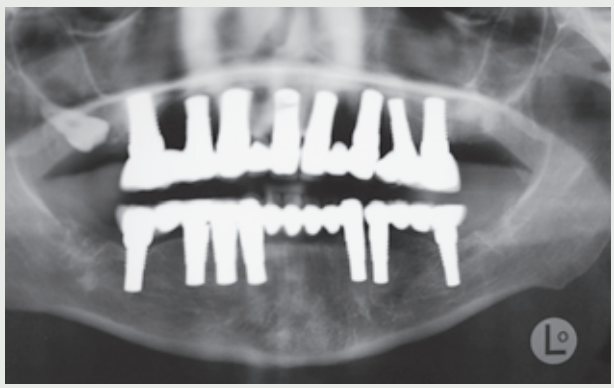


Fig 14 Panoramic radiograph at the 3-year follow-up.

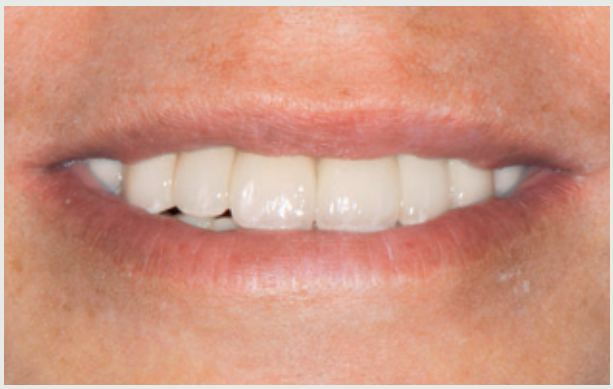


Fig 15 Smile appearance at the 3-year follow-up.

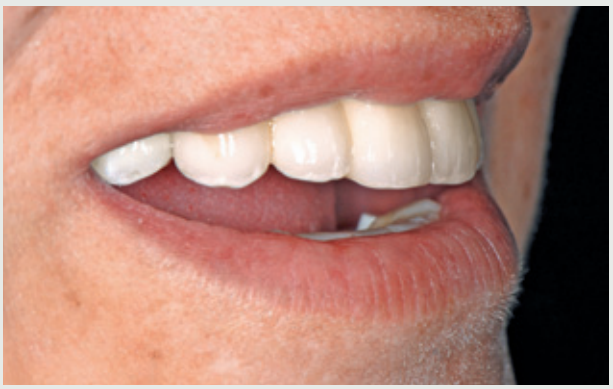


Fig 16 Lateral aspect of the smile.

ZrO_2 implants may offer a good alternative to Ti implants in appropriate cases. The biocompatibility of ZrO_2 material is generally accepted and rough surface ZrO_2 implants seem to have improved bone-to-implant contact scores when compared with smooth surface ZrO_2 implants. However, the long-term prognosis of the CeraRoot acid-etched (ICE) surface is yet to be demonstrated. The mechanical properties of ZrO_2 dental implants have also been studied in different publications. It has been shown that ZrO_2 implants have sufficient strength to be used as dental implants. However, preparation with diamond burs might alter this mechanical strength and compromise the long-term integrity of implants.[45] For this reason, it may be prudent to use ZrO_2 dental implants that require no preparation. Y-TZP low-temperature degradation, and chipping of porcelain veneering are issues that still remain under investigation.

During the healing phase of the present case report, no temporary restoration was placed until the implants had achieved good osseointegration. No scientific evidence, experience or long-term results are available today to support immediate function with ZrO_2 implants in full-mouth oral rehabilitations. For this reason, the authors decided not to provide immediate provisionalization and function. The authors considered the present case very challenging and it was also expressed to the patient. In order to avoid premature function and overload of the implants, especially in the grafted areas, the patient was left on a soft diet for 2 months until complete osseointegration had occurred. Whilst this approach, without any immediate provisionalization, might not be accepted by the majority of today's patients, there may be an indication for special treatment approaches in such cases. In addition, future research may also validate immediate provisionalization of ZrO_2 implants as a possible treatment protocol. The potential risk of implant failure could have been reduced by performing the surgeries by quadrants or even sextants. However, the total treatment time would have also been greatly increased. Finally, the risk of implant fail-

ure due to premature overloading was considered to be acceptable and reasonable given the patient's treatment commitment.

Regarding the prognosis of CeraRoot ZrO_2 implants with ICE surface, there are no published long-term clinical data. This case report is part of an ongoing clinical study[50] of which preliminary results have been published previously. The 5-year follow-up will soon be published with an expected success rate of around 95%. Moreover, no implant fractures, peri-implantitis, or bone loss have been reported. Prosthetically, no fractures of any zirconia substructure have occurred, and chipping of the veneering porcelain was very rare. This was attributed to well-designed zirconia frameworks with special attention given to providing the correct support to the porcelain on the occlusal, lingual, and interproximal aspects of the restorations.

Conclusions

Although this paper represents a case report from an ongoing clinical study, it shows that even complex and highly esthetically demanding cases can be treated successfully with ZrO_2 implants and ZrO_2 restorations. To the authors' knowledge, the present article is the first to report a full-mouth oral rehabilitation with ZrO_2 implants and ZrO_2 restorations. Although the little available scientific evidence concerning ZrO_2 implants is very promising, long-term investigations are needed to demonstrate the success, stability, and integrity of CeraRoot ICE surface implants.

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