# The evolution in ceramic implantology: the two-piece implant. A review of the literature and report of two cases

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KEYWORDS

*Ceramic implantology, Two-piece implants, Zirconia implants.*

ABSTRACT

Aim: *In recent years, research in oral implantology has focused on alternative materials to titanium. Zirconia implants, used at first in their one-piece variant, have been further developed thanks to the introduction of the two-piece version. The present review aims to describe the peculiarities of two-piece zirconia implants, based on scientific literature in order to understand the current success rate of these implants, their indications, morphological characteristics, as well as advantages and disadvantages and clinical indications such as in full-arch rehabilitations.*
Case report: *Two cases are reported in which the submerged technique was used, therefore during this stage patients wore an immediate removable prosthesis with soft direct relining. For the final prostheses wax models and duplicates of the provisional prosthetics where used. Final results are reported at the 3year and 18-month follow-up.*
Conclusion: *The growing demand for metal-free restorations even for complex treatments, such as full-arch restoration in edentulous patients, spurred research on alternatives such as zirconia implants. Two-piece zirconia implants are indicated in cases where implant parallelism is necessary, when there is poor bone quality (bone D3/D4), partial edentulism, restoration of the posterior quadrants, space limitations at the time of implant insertion and in full-arch/full-mouth rehabilitation of edentulous patients.*

## Introduction

The search for biocompatible materials as an alternative to titanium for dental implants has led dentistry to the use of innovative materials that can overcome some of the issues with titanium. Additionally, the increasing aesthetic demands from patients, particularly for their anterior teeth, show that failing to achieve a highly aesthetic restoration ultimately means an overall unsuccessful result, despite having functional success (1).

Aluminium oxide ($Al_2O_3$) was one of the first ceramic materials used for implants. However, it was quickly abandoned because, although it osseointegrated, its mechanical properties proved insufficiently resilient to mastication. As a result, ceramic implants lost their appeal and eventually manufacturers withdrew them from the market. The arrival of zirconia a material with good mechanical properties, high biocompatibility and with excellent aesthetic result encouraged researchers to investigate its possible use as a material for endosseous implants.

Zirconia implants have enabled modern implantology to overcome the limitations of titanium, which are especially in terms of restoration in the anterior quadrant of patients with thin gingival biotype, but also in terms of immunological response to the implant material. It had been discovered that, according to the Gell and Coombs classification, type IV immunological reactions can occur following implant placement and/or restoration using titanium. These reactions result in stimulation and proliferation of a population of reactive T-lymphocytes. This kind of situation is difficult to ascertain prior to implant placement because of the unreliability and inaccuracy of skin patch tests (2). The literature indicates the presence of a demonstrable immunological reactivity in about 5% of patients with titanium implants. Using more sophisticated and sensitive diagnostic methods, such as LTT lymphocyte transformation tests, it has

been possible to reveal immunological reactions in patients exposed to titanium implants (3) at even higher percentages.

The first zirconia implants produced were in one-piece . Acknowledging the limitations in one-piece implants, ceramic implant manufacturers have recently introduced the two-piece type which consists of an implant and a prosthetic abutment that can be connected by means of a screw or by cementation.

## Choosing between two-piece or one-piece implants

One-piece implants were the first zirconia implants introduced for clinical use and proved to perform well in terms of osseointegration and clinical implant success (4,5,6,7). These implants definitely have advantages, but also a number of limitations resulting from their monoblock morphology.

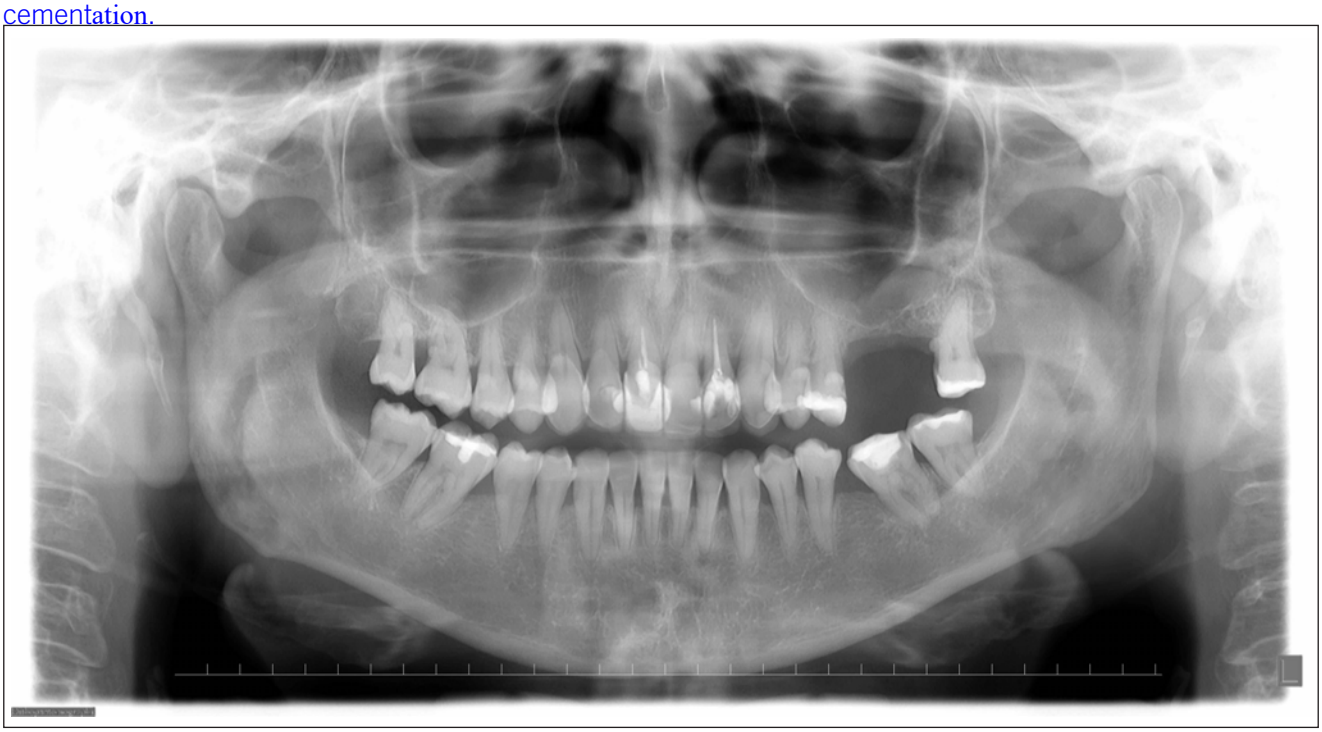


Figure 1 Initial orthopantomograph

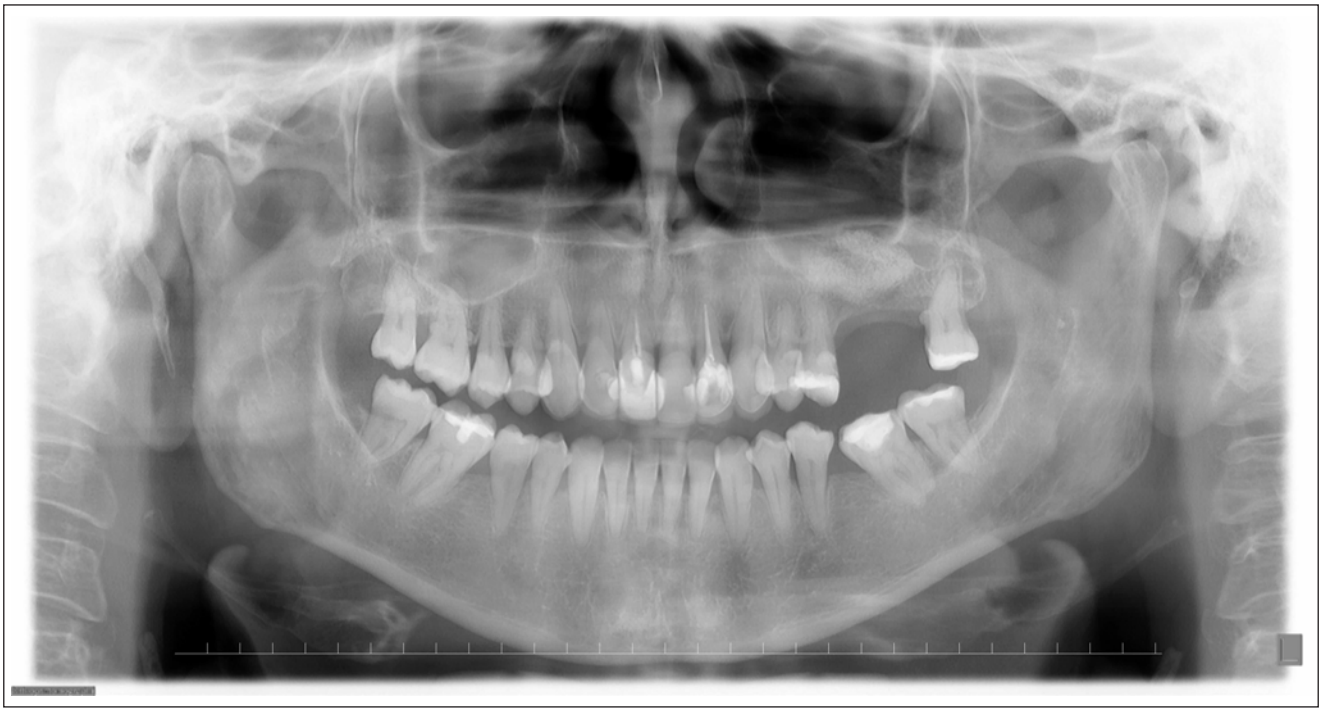


Figure 2 Orthopantomograph after sinus augmentation with bone graft

One-piece implants are particularly suitable for the anterior quadrants especially in the case of thin biotypes, for the restoration of single-tooth edentulism, and in patients who have optimum bone support that is able to withstand mastication or other forces during the osseointegration phase. However, even when there is good bone support, the monolithic structure of these implants can lead to difficulties in terms of surgical insertion in patients with limited opening, short clinical crowns and limited interocclusal space. Moreover, achieving paralellism of the abutments at the time of restoration may be very challenging since most one-piece implant manufacturers do not recommend grinding or adjusting the abutment due to the risk of inducing cracks in the implants. While with two-piece implants, this problem is easily overcome by using angulated abutments. On the other hand with one-piece implants it is necessary to create parallelism in-situ by grinding the abutment with significant risks. Modifying the abutment in this way to adapt it to the requirements of the prosthesis results in structural alterations that could weaken the zirconia and make it less resistant to fracture, particularly in the posterior quadrants where the chewing forces are highest. Additionally, the use of one-piece implants necessarily involves the positioning of a temporary tooth that must be free of occlusion and lateral contact. However, studies have shown that these implants are subjected to loads (8) linked to the physiological movements of the tongue and to uncontrolled forces in chewing cycles (9). This may undermine the osseointegration processes, particularly where the bone support is of poor quality, a clinical situation found frequently in the maxillary bone. It has been shown in the literature that an implant placed in poor quality bone with thin cortical bone and low trabecular density (D4) has a greater probability of failure compared to implants inserted in other types of bone quality (10). This occurs not only in situations where the bone does not have sufficient density on immediate load, but also where regenerative procedures are carried out (GBR, sinus lift, trans-sinus lift) where, in any case, it would be preferable to adopt the submerged implant healing technique to avoid pressure during the phase of bone healing and implant osseointegration (Figure 1, 2, 3).

Two-piece implants, on the other hand, are more versatile than one-piece implants in the situations described above, since the dentist can opt for submerged healing of the implant in cases where this situation is indicated and can choose between different types of abutment. For instance, for the restoration of the posterior quadrant in patients who are significantly hindered from opening their mouths wide, two-piece implants together with angulated abutments are ideal since they also reduce the potential of occlusal pre-contact compared to straight abutments. Furthermore, as already mentioned above, when the bone quality of a patient's bone structure is poor or in cases where it is necessary to opt for regenerative procedures (Figure 4), with the two-piece implants it is possible to proceed with the submerged healing of the implant to prevent chewing pressures disrupting the healing and osseointegration or causing unwanted movement of the implant axis due to poor primary stability.

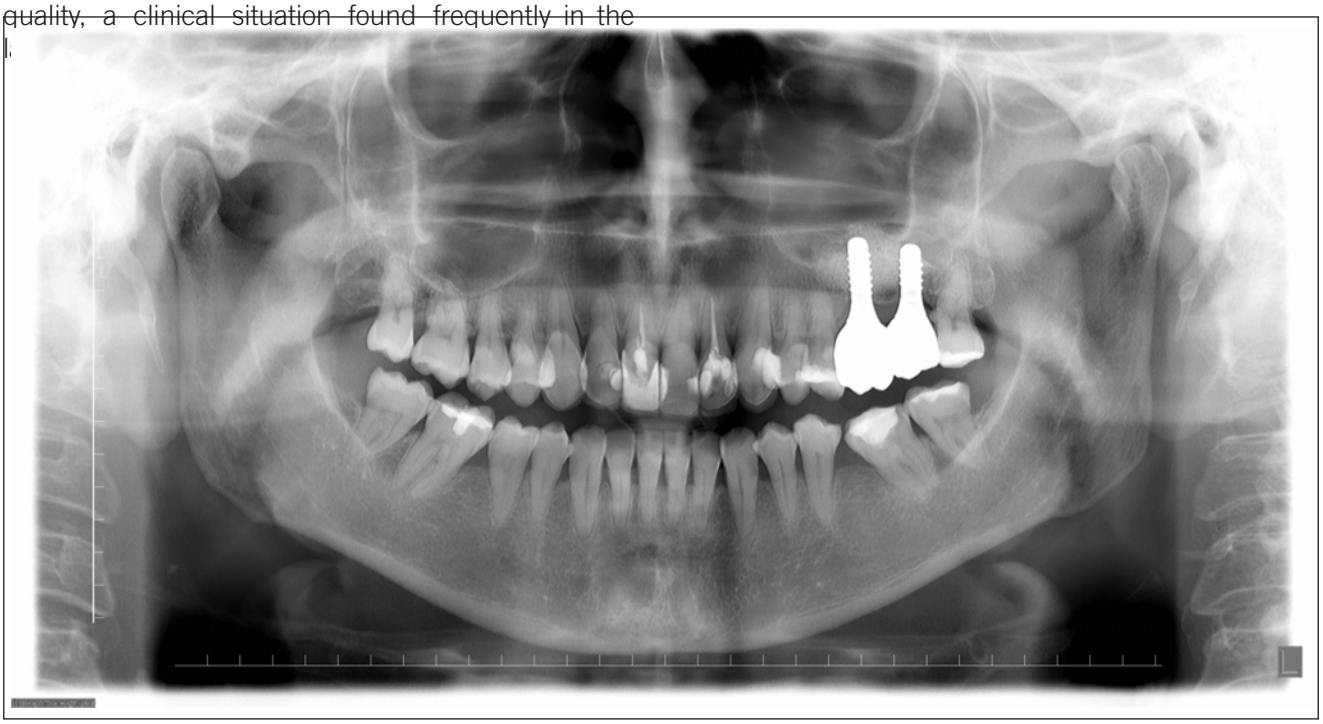


Figure 3 Orthopantomograph after implant prosthodontic rehabilitation with zirconia implants

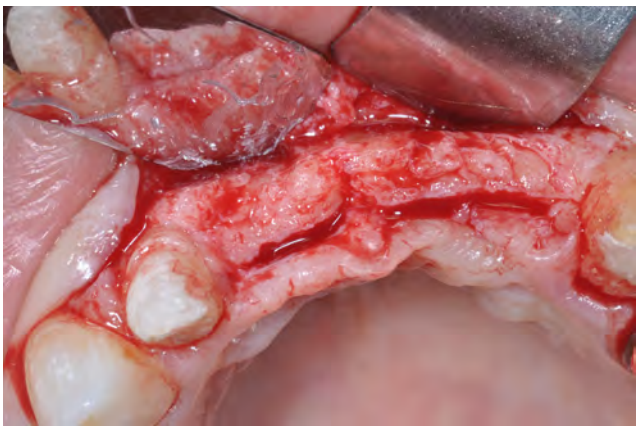


Figure 4a Full thickness flap in the front area

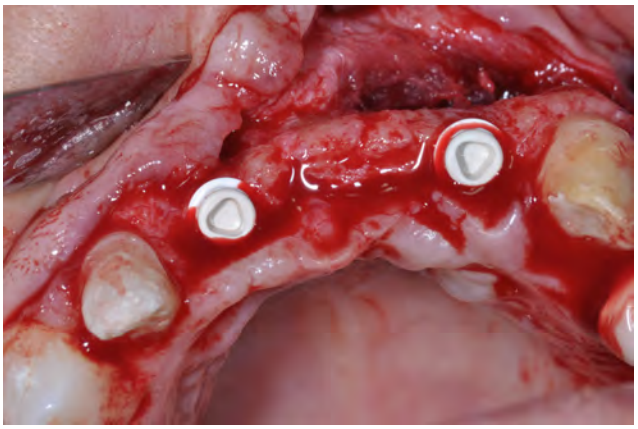


Figure 4b Surgical site after placement of two two-piece zirconia implants

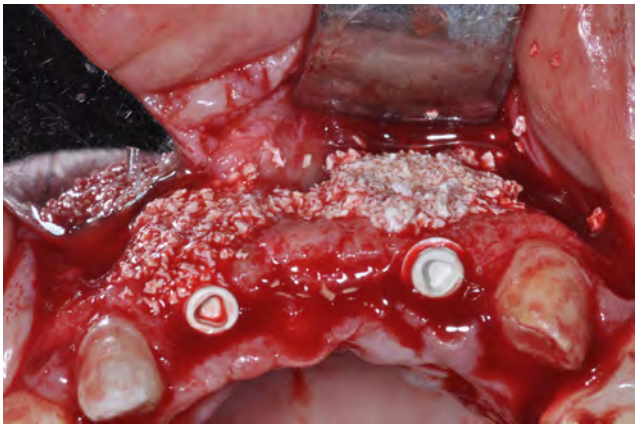


Figure 4c Placement of the bone graft

However, compared to the single-piece implant, the two-piece implant system can cause problems that were already partly found in titanium implants. These issues occur at the implant-abutment interface owing largely to the greater risk of bacterial colonization in the micro-gap that can be created at the abutment-implant juncture (11). Nonetheless, it should be noted that zirconia has intrinsic characteristics that entail a lower risk of contamination than titanium since bacteria do not have the fundamental

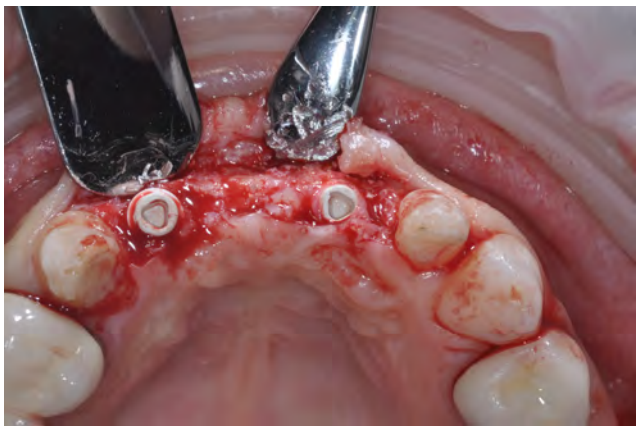


Figure 4d Reopening of the surgical site

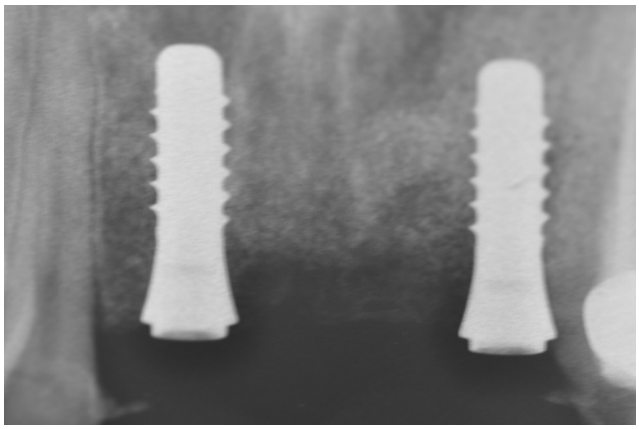


Figure 4e Intraoral radiograph of zirconia implants in the front area

components for adhesion to ceramic material (12). In any case, procedures can be performed to minimize the risk of bacterial colonization. For example, some manufacturers have directed their production towards a different interface between the implant-abutment i.e. the «Morse taper» with a hex connection. This implant-abutment relationship not only ensures high stability of the abutment, preventing potential rotational movements by the prosthesis because of the hexagonal connection, but also a greater protection of the hexagonal seal given by the conical closure that reduces the gap between implant and abutment preventing bacterial infiltration (13).

## Clinical success of two-piece zirconia implants

The success and survival rate of implants in zirconia are comparable to those of titanium implants, and several authors have compared the two implants (Zr-Ti) in order to evaluate their clinical reliability (14). A recent review of the literature conducted by Haro Adánez Mireira et al. (15) on 17 clinical studies has observed that, for a total of 1704 zirconia implants (1521 one-piece, 183 two-piece), monitored for a period of between 1 and 7 years, the average survival

Figure 5 Cylindrical zirconia implant

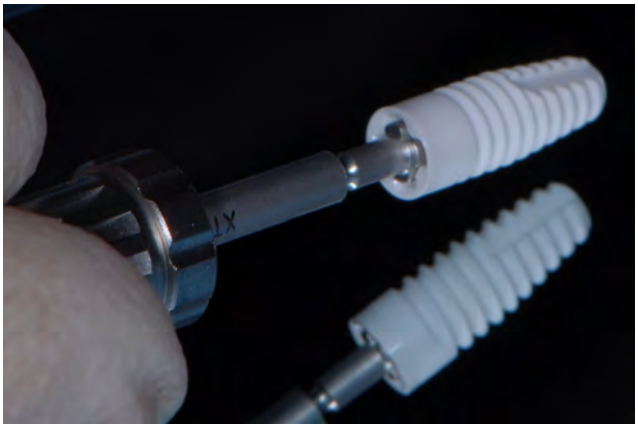


Figure 6 Conical zirconia implant

rates are 95% (95% CI 91-97%).

In addition to the survival rate, the review also examined average marginal bone loss values after 1 year and at the end of the follow-up period. Overall, the marginal bone loss was respectively 0.89 mm (CI 95% 0.60-1.18) and 0.98 mm (CI 95% 0.79-1.18).

Regarding studies on two-piece zirconia implants, the results obtained in terms of implant success and survival have shown data comparable to those of titanium implants. Specifically, in a study conducted by Payer et al. (16), the success rate and survival rate were 93.3% for zirconia implants and 100% for titanium implants at a 24 month follow-up. Similar values have also been reported by Cionca et al., (17) which showed a survival rate of 87% just for zirconia on patients monitored for 588±174 days.

The clinical success of two-piece zirconia implants was also evaluated in a retrospective survey conducted by Jank et al. (18), in which they examined the data for implant replacement under guarantee by a well-known implant brand. The period investigated, between 2010 and 2014, examined three generations of two-piece implants. The results of this study reveal that two-piece zirconia implants have competitive success rates. The success rate has progressively increased, with initial levels higher than 96.7% in the first generations, up to levels exceeding 98.5% in the latest generations.

## Implant designs

As with titanium implants, the same implant morphological principles apply to implants in zirconia. The ideal shape for an implant is cylindrical (Figure 5) or slightly conical (Figure 6) and it must also have a thread along its surface to distribute the axial load at the implant head along the entire thread. Thus, each thread contributes to resisting and supporting the occlusal load while the apex is orthogonally opposed to it. The implant's ability to withstand occlusal load enables its long-term survival without loss of osseointegration. This implant shape, however, does not well support the oblique forces that are concentrated at the implant apex and neck. In fact, it is necessary to ensure prosthetic designs that lead to only having vertical/axial forces.

Two-piece zirconia implants are available in both the cylindrical version (Straumann® Pure Ceramic, Straumann AG, Basel, Switzerland; Z3c/Z3s Z-Systems AG, Oensingen, Switzerland; Zeramex® P6, Zeramex®, Dentalpoint AG, Spreitenbach, Switzerland; TAV Zirconia two-piece implant, TAV Dental Germany GmbH, Hamburg, Germany) and conical (Ceralog® Hexalobe, Camlog Biotechnologies AG, Basel, Switzerland) and are threaded along the entire surface.

Some commercially available implants also have cylindrical-conical models (Zeramex® XT, Zeramex®, Dentalpoint AG, Spreitenbach, Switzerland; NobelPearl, Nobel®, Nobel Biocare Italiana, Vimercate; SDS 2.0, SDS Swiss Dental Solutions AG, Kreuzlingen, Switzerland).

## Screw or cement-retained abutment?

As already mentioned, in the two-piece system, the implant can be connected to the abutment in two different ways: screwed or cemented.

The screwed connection method involves a connection screw between the implant and the abutment, that can be made of titanium, gold, PEEK or carbon-PEEK.

Gold and titanium screws are found in some types of two-piece zirconia systems (Ceralog®, Camlog Biotechnologies AG, Basel, Switzerland; TAV Zirconia two-piece implant, TAV Dental Germany GmbH, Hamburg, Germany; Z3s Z-Systems AG, Oensingen, Switzerland). Using implants with these screws means that the restoration cannot be defined as completely metal-free, although it should be specified that the metal connection screw is not in direct contact with the patient's tissues.

The carbon-PEEK screws (Figure 7) are made of carbon fibre reinforced PEEK (Vicarbo®, Dentalpoint AG, Spreitenbach, Switzerland). This material is not

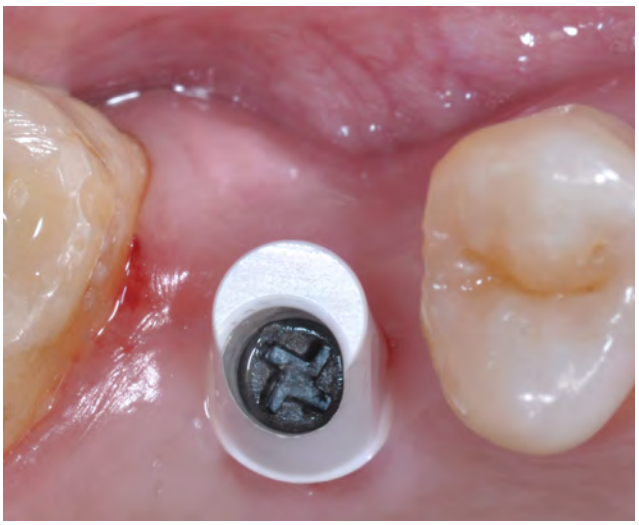


Figure 7 Abutment screwed with carbon-peek connection screw

radiopaque, with an elastic modulus >160 GPa, flexural strength >1100 MPa, tensile strength 2000 MPa and is biocompatible according to ISO10993. Its specific feature is in its intrinsic structure as the carbon fibres are continuous and go in a longitudinal direction (60% CF) and are held in a matrix of PEEK (Polyetheretherketone 40%). This provides a significant clinical advantage in the tightening of the screw which, thanks to the presence of longitudinal and continuous carbon fibres, adapts to the internal thread of the implant and can support the tension forces.

However, such adaptability also implies the disadvantage of the screws deteriorating after first use, and they are guaranteed by the manufacturer only for a single tightening of the screw. The recommended maximum tightening torque is up to 25 Ncm and, as previously stated, it is advisable to do it only once.

Several two-piece systems involve the use of carbon-PEEK connection screws (Zeramex® P6 and XT, Zeramex®, Dentalpoint AG, Spreitenbach, Switzerland; NobelPearl, Nobel®, Nobel Biocare Italiana srl, Vimercate, Italy).

The use of screws in a material different from zirconia can be a critical point of implant restoration, since stress areas can be concentrated in the connection point with the screw. Carbon-PEEK connection screws have proven to be able to better withstand the tension forces thanks to their intrinsic adaptation capacity.

A study conducted by Spies et al. (19) corroborates the stability under stress of the carbon-PEEK connection screw. In this article, systems with a carbon-PEEK connection screw were evaluated together with control groups subjected to cycles of hydrothermal aging (85° for 60 days) and to dynamic load cycles (for 107 days). The results of this work showed that the carbon-PEEK screw has a good clinical reliability, even under stress.

Another common problem of all the systems that involve a connection screw is the possibility that it can become unscrewed. In order to avert this risk, some two-piece zirconia implants have a pre-mounted clamp wedge that is located inside the implant and keeps the screw fixed to the abutment. In this type of implant, the risk of screw loosening is therefore fairly limited (Z3s Z-SYSTEMS AG, Oensingen, Switzerland).

As regards connections by luting cements for two-piece zirconia implants, these require the use of a specific cement that will join the abutment to the implant. This implant type allows the two-piece to be treated in a similar way to the one-piece type. Cements recommended for luting differ according to the manufacturer's indications but generally belong to two categories: glass ionomer cements (Ketac™ Cem, 3M™ Espe, 3M Italia S.p.a, Pioltello, Italy) and resin cements (Panavia™ 2.0, Kuraray, Kuraray Europe GmbH, Hattersheim, Germany; RelyX™ Unicem, 3M™ Espe, 3M Italia S.p.a, Pioltello, Italy; Els cem, Saremco Dental, Saremco Dental AG, Rebstein, Switzerland).

The operative phases concerning the cementation are very simple, which means it can be used even by less experienced operators. However, this type of connection has some disadvantages, specifically because of cementation. One of the main disadvantages regards the removal of cement residuals that can be very difficult, especially if it is subgingival. In addition, the use of cements introduces critical issues related to the type of material used (product characteristics) and its clinical duration.

Since the decementation of an implant is a not infrequent complication, even for two-piece implants, the abutment may become detached from the implant owing to decementation.

Besides the detachment of the abutment, the greater problem lies in the fact that, in the initial phases of decementation, there are micro-movements of the structure. These, by creating areas of stress, can lead to fractures in the implant structures. However, it emerges from the literature that the loss of retention of the abutment has never been recorded for two-piece implants with cemented abutments using self-curing resin cements (16,17), thus confirming the stability of the cemented connection. In addition, in order to increase the stability of the connection, abutments have recently been introduced that have a ring in PEEK at the base (Zeralock™ PEEK ring, Zeramex®, Dentalpoint AG, Spreitenbach, Switzerland). These abutments used on two-piece implants with dedicated internal morphology (Zeramex® T Zeralock™, Zeramex®, Dentalpoint AG, Spreitenbach, Switzerland) enable mechanical fixing by a rotational movement of 60°.

Of particular interest are the systems that involve a combination of the two connection techniques, as they

require both a micro clamping screw and cementation (SDS2.0, SDS Swiss Dental Solutions AG, Kreuzlingen, Switzerland). These micro screws can be made of titanium, gold or PEEK (in the case of patients with metal allergies). The tightening for the titanium and gold micro-screws must not exceed 15 Ncm, while for the PEEK micro-screws it must not exceed 5 Ncm. Every effort is made to avoid a micro-gap during cementation of the abutment, but it is not always achieved. To reduce the presence of a micro-gap, some implants have a designed space at the implant-abutment juncture which is created to form a hermetic seal. This is brought about by inserting the cement of the fixed prosthesis, which combines with the cement of the abutment and creates a seal that does not allow bacterial infiltration (Z3c Z-SystemS AG, Oensingen, Switzerland).
With regard to abutment fractures, the fracturing of the abutment has been recorded in only a few clinical studies (17, 20,) and, when it occurred, the fracture line was located at the base of the connection (17). In these cases, the remains of the abutments could be easily removed from the implant and a new prosthesis could be made without further complications.

## Implant connections

The abutment-implant connection is an important variable in the distribution of mastication loads from the prosthesis to the bone-implant interface (Figure 8). Unfortunately, the connection is a point of discontinuity and weakness in the system. Ideally, a connection should be:

- precise (to guarantee the maximum possible seal between abutment and implant in order to minimize the possibility of bacterial adhesion and proliferation);
- stable (to ensure adequate resistance to mastication stresses, the two connected components must not be allowed to move against each other, whether these are rotary torsion or bending movements);
- simple (to ensure maximum practicality of use for the clinician both during surgery and when loading the prosthesis).

The implant connections for zirconia implants, like for titanium implants, are currently divided into the following types.

- External hex connections (Zeramex® P6, Zeramex®, Dentalpoint AG, Spreitenbach, Switzerland).
- Internal hex connections (Ceralog® Hexalobe, Camlog Biotechnologies AG, Basel, Switzerland; W Zirconia two-piece implant, TAV Dental Germany GmbH, Hamburg, Germany).
- Internal multi-lobe connection (NobelPearl, Nobel®, Nobel Biocare Services AG, Kloten, Switzerland; Zeramex® XT, Zeramex®, Dentalpoint AG, Spreitenbach, Switzerland).

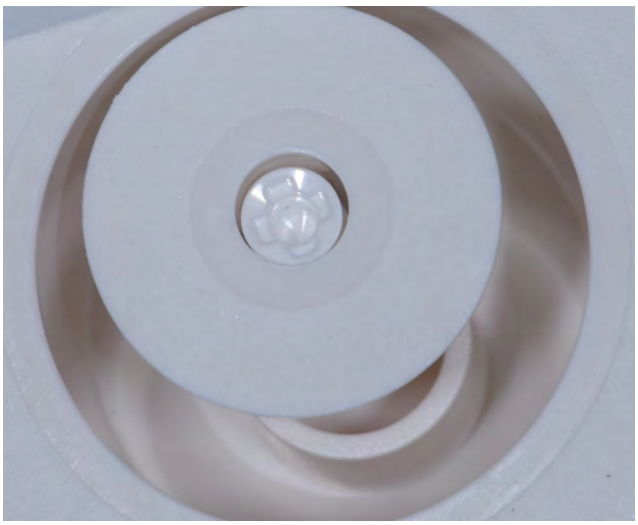


Figure 8 Two-piece zirconia implant with quadrilobate internal connection

- Internal cone connection (Z3c Z-Systems AG, Oensingen, Switzerland; SDS® 2.0, SDS Swiss Dental Solutions AG, Kreuzlingen, Switzerland).
- Internal square connection with parallel sides (Straumann® Pure Ceramic, Straumann AG, Basel, Switzerland).

The external hex connections have an external hexagon at the neck of the implant with an anti-rotational function. The cylindrical base of the abutment rests on the edge of the implant. Hexagonal indexing guarantees a solid anti-rotational protection and a safe and simple positioning of the abutment.
External connections allow in some cases the simplified engagement of the implant in several possible positions (Zeramex® P6, Zeramex®, Dentalpoint AG, Spreitenbach, Switzerland) and also, for the prosthetic stages, they allow an indirect grip of the impression free of tension.
In the connections with internal hexagon, the walls of the implant neck are flared towards the inside and end with an anti-rotational hexagon. The internal hexagon allows the diffusion of the forces tangentially and provides good anti-rotational stability (Ceralog® Hexalobe, Camlog Biotechnologies AG, Basel, Switzerland).
The internal four-lobed connections facilitate the correct positioning of the implant as the four retention elements in conjunction with the four abutment hooks enable the abutment to be easily positioned (NobelPearl, Nobel®, Nobel Biocare Services AG, Kloten, Switzerland; Zeramex XT, Zeramex®, Dentalpoint AG, Spreitenbach, Switzerland).
In the internal cone connections (Z-System® Z3c, Z-Systems AG, Oensingen, Switzerland; SDS® 2.0, SDS Swiss Dental Solutions AG, Kreuzlingen, Switzerland) the abutment, whose profile is tapered, is inserted into the housing inside the implant, becom-

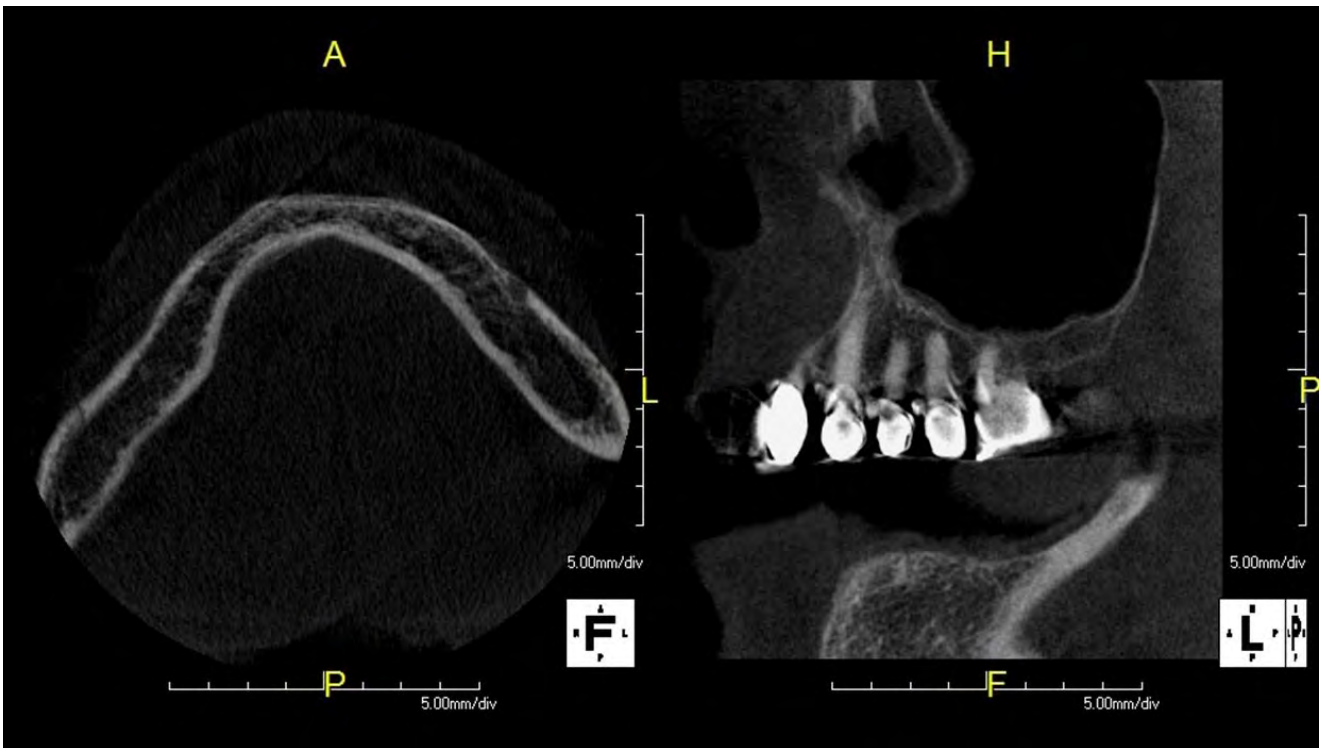



Figure 9 CBCT scan of the initial situation

ing an integral part of the implant by means of a conical coupling. However, it does not have an anti-rotational function.
In the internal square connections there is a flat-to-flat connection, which increases its stability at the expense of prosthetic flexibility. They are also characterised by the presence of a rotational block and an internal thread for fixing the provisional and final components (Straumann® pure Ceramic, Straumann AG, Basel, Switzerland).

## Implant surfaces

The surfaces of ceramic implants have been constantly evolving over the years, which has been necessary to achieve higher performance characteristics for improved osseointegration.
It is known that osseointegration of titanium implants is increased by altering their surface, and therefore it has been hypothesised that this effect could also occur on zirconia implants.
The first in vivo and in vitro trials (21,22) took into consideration the surface changes of zirconia in order to evaluate their effect on the osseointegration ability and on the mechanical characteristics of the biomaterial.
The most frequently used zirconia surface treatments involve mechanical and chemical subtractive processes. Mechanical modifications include machining processes and sandblasting processes, while chemical ones include etching processes. In general, chemical treatments lead to an improvement of the morphological alterations since, in topographic terms, they create a more uniform surface than just sandblasting. Sandblasting processes can be performed using different materials; currently the material most used is aluminium oxide. Sandblasting with aluminium oxide in Y-TZP implants, performed before the sintering process, avoids the zirconia transforming from the tetragonal phase to the monoclinic phase, so as to avoid undermining its properties. In their guidelines, Wennerberg and Albrektsson stressed the importance of using several parameters to increase the roughness of an implant (23,24). This aspect is justified by the fact that using only one parameter fails to guarantee an adequate spatial distribution in the surface topography. For this reason, it has been noted that the use of both processes (chemical and mechanical) provides a greater increase in the bone adhesion and proliferation on the implant surface. In detail, sandblasting ensures an adequate bone adhesion, while acid etching evens out the topography of the implant, smoothing the peaks. In fact, a recent study has observed a superior bone bonding around sandblasted and etched implants compared to those that had undergone sandblasting treatment only (25). However, it is important to underline that while both treatments improve the maintenance of osseointegration they do not increase its speed: it is not possible to establish which of the two treatments has a greater effect on bone growth.
The growth of osteoblasts on these implant surfaces treated both chemically and mechanically has been widely documented (18).

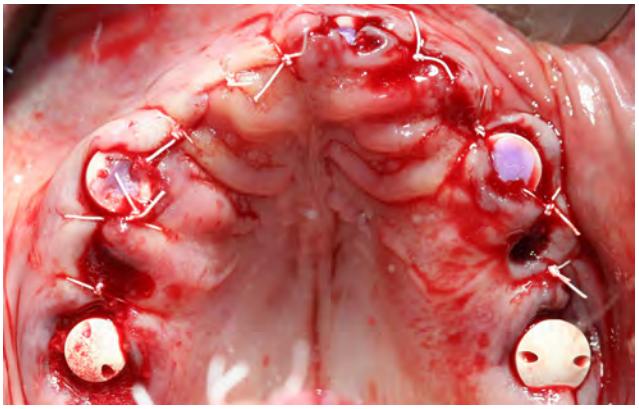


Figure 10 Occlusal view of the maxilla after implant surgery

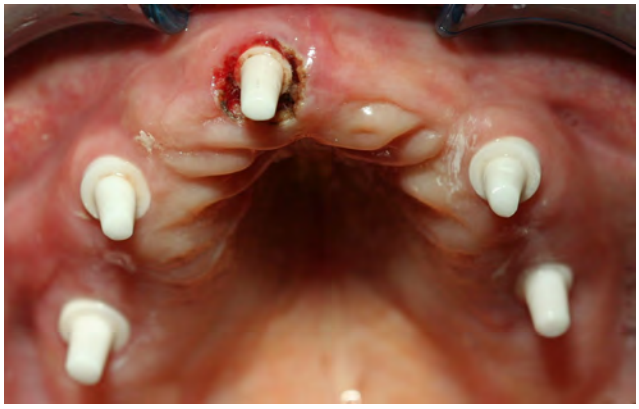


Figure 11 Positioning of the abutments

A study conducted by Gahlert et al. (6) confirmed that the increase in the rough surface of sandblasted and etched zirconia implants has an important influence on bone integration and bone stability. A greater torsion strength during removal was also noticed.
The latest generations of systems have seen the entry of LASER technology among surface treatments. The results of these treatments not only determine a rough thread, but also allow to achieve an optimal degree of roughness at microscopic and macroscopic level (2-3 μ) (26).
Of the various types of laser usable for this treatment, a study conducted by Delgado-Ruíz et al. proposed the use of femtosecond laser as a valid alternative (27).

Full-arch restoration with two-piece zirconia implants
When a full-arch surgical implant restoration is offered by a dentist, it not only restores form and function, but also improves the patient's quality of life. Full-arch implant restoration techniques use a minimum of four implants per arch to treat cases of total edentulism. Malo and colleagues have been pioneers in the concept of full-arch treatment (28,29,30).
Below are reported two cases in which two-piece zirconia implants were used to restore edentulous jaws. The cases were treated with the submerged technique, and during this stage the patients wore an immediate removable prosthesis with soft direct relining (periodically relined). The stages of making the final prostheses involved using wax models and duplicates of the provisional models where present. Case report 1 had a three-year follow-up, while the second case was evaluated after 18 months.

## Case report 1
### Cemented full-arch restoration with two-piece zirconia implants on both arches

An 82-year-old female patient presented for clinical evaluation with a partially edentulous maxillary arch and the mandibular arch completely edentulous. At the clinical examination of the upper arch the remaining teeth resulted unfit for restoration and in the lower jaw a moderate degree of bone resorption was no-ticed. Bone levels and surgical anatomy were as-sessed using a CBCT scan (Figure 9). Several ther-apeutic options were presented to the patient, who decided for a full-arch implant restoration on both arches with two-piece zirconia implants.
The treatment plan was divided into two phases, initially composed of the following procedures: extraction of the remaining teeth in the upper jaw, the immediate placement of the implants in both arches and the delivery of two immediate provisional removable prostheses. Surgical planning was performed using the native software of the Prexion 3D CBCT scanner.
Before starting the surgical phase, the immediate provisional prostheses were duplicated in order to provide the dentist with a surgical guide.
After the patient signed the informed consent, the surgical phase began. After local anaesthesia in the maxilla (bilateral posterior alveolar nerve block) and the mandible (plexus anaesthesia), the flaps were prepared by transversal and intrasulcular incisions and exposure of the midline in both arches. The alveolar bone was exposed and the remaining teeth were removed sequentially from left to right. Five ceramic implants were placed in both arches according to the manufacturer's surgical protocol and under abundant irrigation (Figure 10). The torque value for all the implants was between 20 and 25 N/cm. All implants positioned achieved good primary stability.
The patient returned two weeks later for suture removal and then periodically for sixteen weeks. Five months after implant placement, the second therapeutic phase began in which the implants were uncovered using a diode laser. The stability of the implant was assessed subjectively since as yet there is no device designed to measure the stability of two-piece ceramic implants with cemented abutments. After careful cleaning and decontamination of the

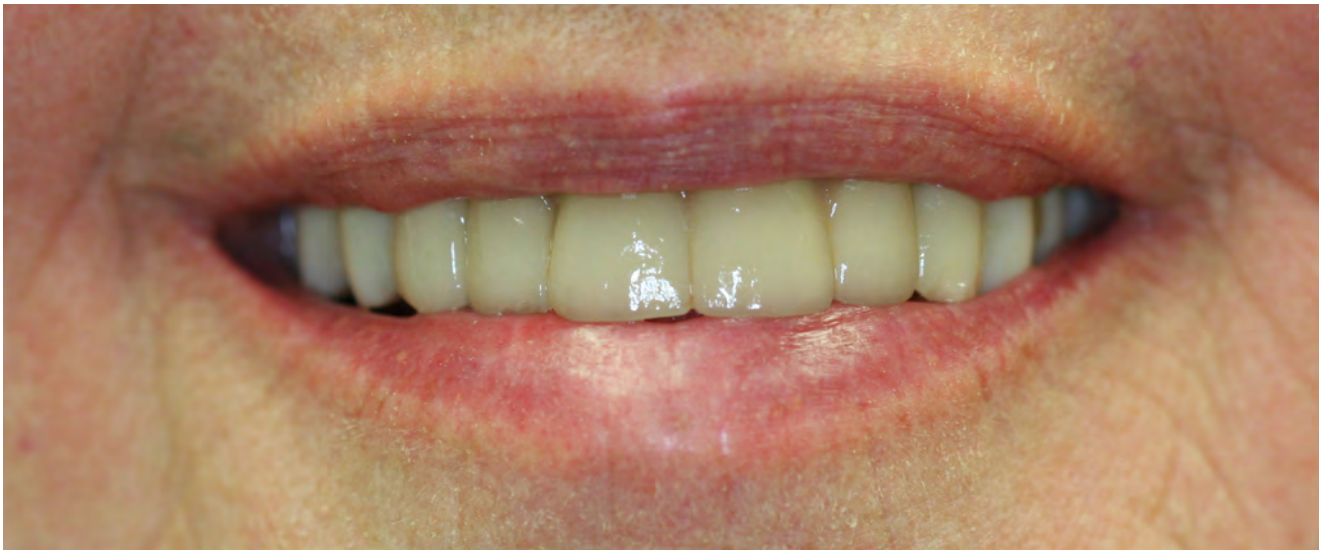


Figure 12 Front view of the patient with the fixed zirconia prosthesis

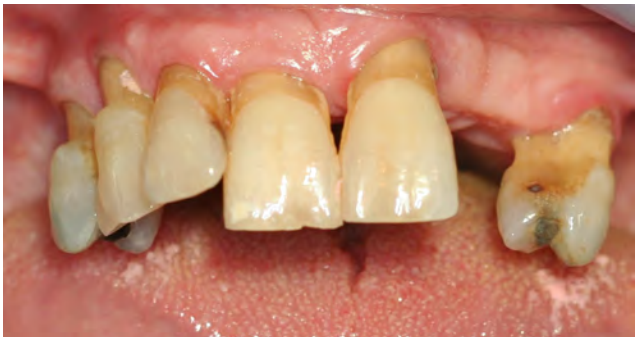


Figure 13 Clinical view of the upper arch

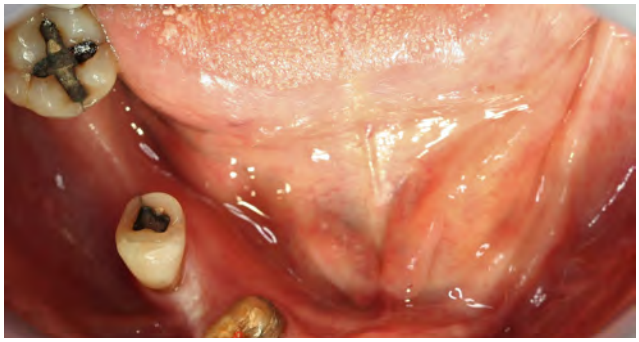


Figure 14 Clinical view of the mandibular arch

abutment and the connection space of the implant, the abutments were cemented to the implants with a resin modified glass ionomer cement (Figure 11).
The impression stage was carried out using a polyvinyl oxane on a closed tray as impression material, after which the impression was scanned in the laboratory to convert it into digital format.
The temporary prosthesis was designed and milled in PMMA. Once the PMMA prostheses were positioned on both arches, occlusal adjustments were performed. The patient wore the provisional prostheses for four months during which aesthetic and occlusal adjustments were made. Once it was established that the patient had not experienced any problems, a scan was performed and a duplicate created with a structure in zirconia (CAD/CAM milling).
A structure test was performed to verify the passive adaptation to the implants on both arches. The structures were returned to the laboratory and, to improve the aesthetic result, the areas of the front teeth from canine to canine were reduced to enable application of lithium disilicate elements. The posterior areas of the prosthesis were made entirely of zirconia. After occlusal adjustments, fixed zirconia prostheses (Figure 12) were cemented to implant-abutment connections following the protocol previously described. This case has been followed up for three years and, at present, no complications have been recorded.

## Case report 2
### Screw-retained hybrid full-arch restoration with two-piece ceramic implants

A 59-year-old male patient presented for clinical evaluation with a partial edentulous situation.
At the clinical examination, most of the remaining teeth had periodontal problems with grade 2 mobility, gingival recession and advanced bone loss (Figure 13, 14). The vertical dimension was severely reduced following significant bone loss.
Bone levels and anatomical structures were assessed by means of a 3D CBCT scan.
The patient hoped for a fixed solution without metal to restore his dental arches. Among the various therapeutic proposals, the patient accepted a full-arch implant restoration of both arches.
Also in this case the treatment plan was split into two phases. The first consisted of the total cleaning with immediate placement of the implants in both arches and with consequent direct delivery of both immediate provisional removable prostheses with

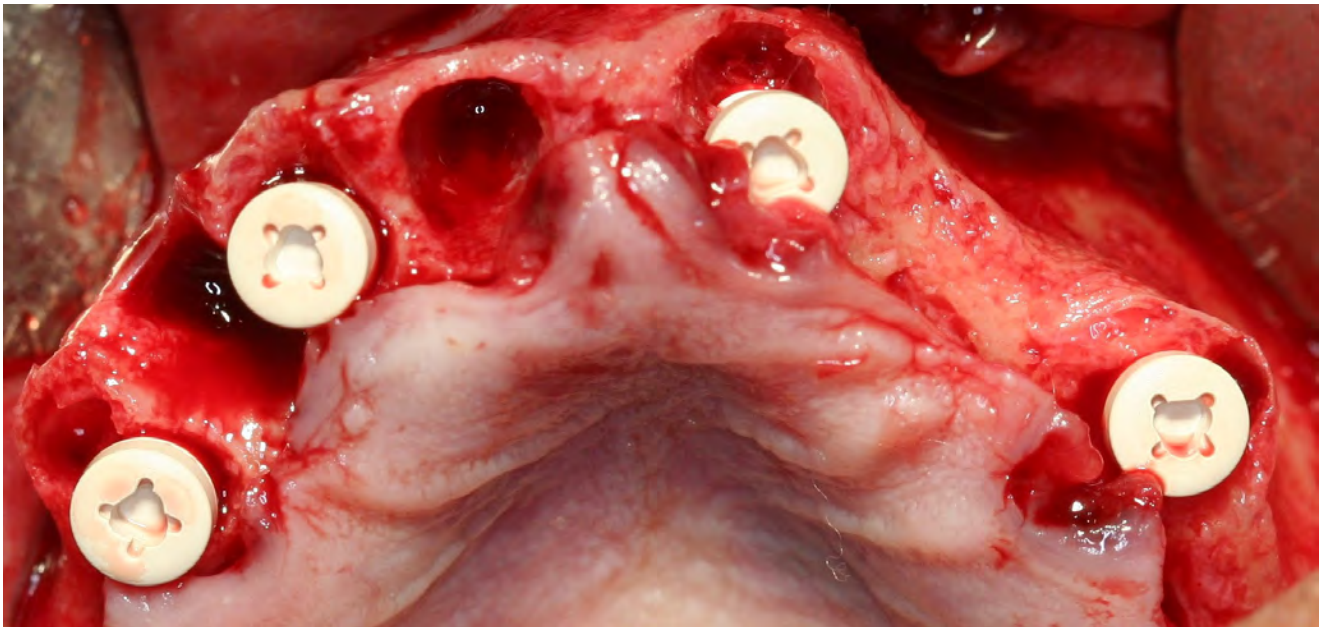
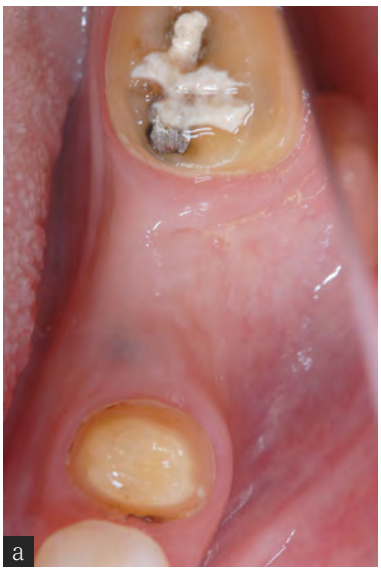


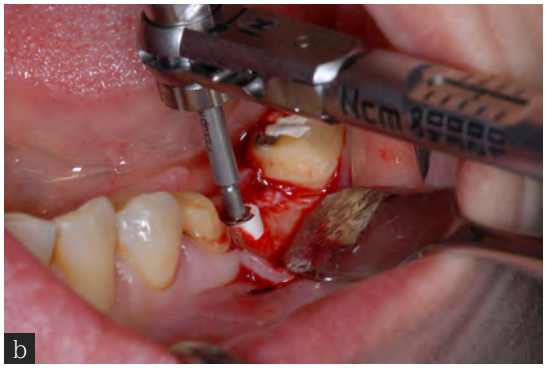
Figure 15 Intraoperative view of the maxilla after placement of the two-piece implants

soft relining. The second stage involved uncovering the implants and positioning the prostheses.
After the patient signed the informed consent, the surgical phase began. Anaesthesia was administered in the maxilla (infiltration with bilateral posterior alveolar nerve block) and in the mandible (plexus anaesthesia).
Atraumatic surgical avulsions were performed using periotomes and taking care to preserve the vestibular cortical bone. Five ceramic implants were positioned in the maxillary and mandibular jaws re-spectively according to the manufacturer's surgical protocol (Figure 15). The torque value was 25 N/cm and all implants showed good initial primary stability. However, one of the mandibular implants failed to osseointegrate and was removed two months after placement. The patient chose not to replace it with another implant. Four months after surgery, the im-plants were uncovered and the soft tissue present above the implant cap screws was removed with a diode laser. The smartpegs especially designed for implants were screwed into the implants and stabil-ity measurements were performed using resonance frequency analysis.
Four months after healing, im-plants stability was measured using the Osstell de-vice (Osstell AB, Gothenburg, Sweden). All implants showed Implant Stability Quotient (ISQ) values above 74. Since the range of acceptable values for the safe loading of dental implants (31) is between 55 and 85, it was determined that the implants were ready for the prosthesis.
The impression stage was carried out using a polyvinyl oxane on a closed tray as impression material, after which the laboratory began the stages of making the hybrid prosthesis.
A number of wax tests were performed to evaluate the correct vertical dimension and the aesthetic and mastication function. Once the wax model was obtained, some clinical photographs were taken and the bite registration was performed. The structure of the zirconia prosthesis was manufactured using CAD/CAM technology by scanning the wax model. A structure test was performed to verify and confirm passive adaptation to the implants on both arches. The structures were returned to the laboratory to overlay the ceramic.
The screw-retained prosthesis in zirconia was attached to the implants and occlusal adjustments were performed where necessary. This has been followed up for 18 months without complications emerging.

## Conclusion

The evolution of ceramic implantology has led to the introduction of two-piece implants, in response to the growing demand for metal-free restorations and to the demand for an alternative that would allow its use in cases where single-piece types in zirconia were not suitable.
For example, two-piece implants are indicated in cases of disparallelism, poor bone quality (bone D3/D4), intercalated edentulism, restoration of the posterior quadrants (Figure 16), regenerative therapy, operative difficulties in implant insertion and in full-arch restoration of edentulous patients.
In fact, with the ageing of the population and the presence of increasingly well-informed patients there has been an increase in requests for metal-free for even the most complex treatments such as full-arch restoration in edentulous patients.





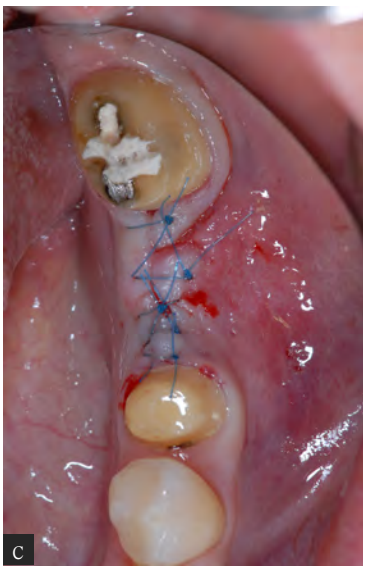


Figure 16a Pre-operative view showing edentulism of 3.6

Figure 16b Placement of the two-piece zirconia implant

Figure 16c Flap closure by first intention

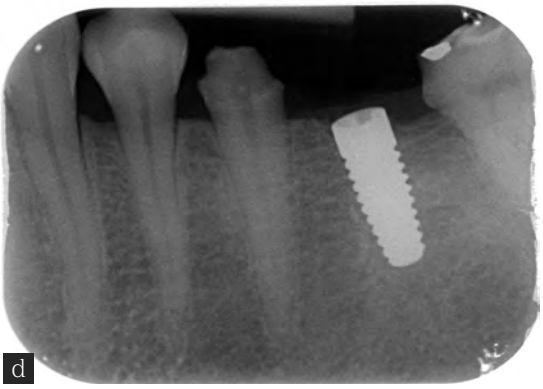


Figure 16d Intraoral radiograph with two-piece zirconia implant in place of 3.6

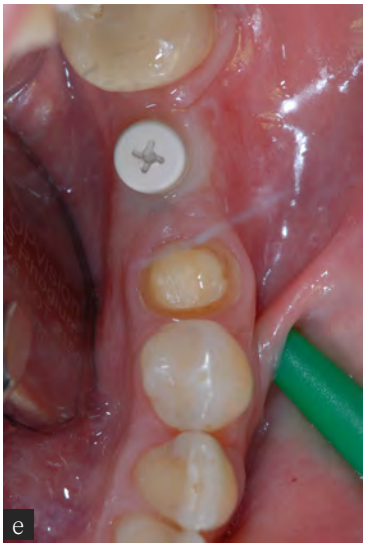


Figure 16e Clinical view after placement of the healing screw

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