Immediate and fixed implant-prosthetic rehabilitation of the completely edentulous jaws: the "Roman Bridge Protocol"

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ABSTRACT

Aim The aim of this study was to describe a new technique for implant-prosthetic rehabilitation of the edentulous jaws, based on both scientific evidences and our own clinical records, named "Roman Bridge Protocol". Completely edentulous jaws is a very critical condition that requires an urgent solution in order to satisfy multiple expectations and needs from patients. Standard removable prosthesis does not represent a valid approach since this solution is not able to gratify both clinician and patients. Nowadays, there are several implant-prosthetic options, such as the "All-on-4" technique, which can restore a good aesthetic and efficient dental arch by the use of total fixed prosthesis anchored to dental implants. Total, fixed and immediate rehabilitation represents a very interesting alternative approach.

Materials and methods Our technique consists of an implant-prosthetic rehabilitation of completely edentulous jaws or future completely edentulous jaws. In this second case, it is necessary to proceed with multiple teeth and immediate post-extraction implants that have to be positioned. The surgical procedure considers the use of only four loaded implants, based on the "All-on-4" surgical protocol, of which two distals and two mesials. The implant-prosthetic approach, instead, will use an immediate function Toronto Bridge application within 24 hrs. Our study described an improved and integrated implant-prosthetic technique based on the "All-on-4" concept. Our diagnostic, surgical and prosthetic protocol further ameliorate this procedure, in order to make it more reproducible in everyday dental practice, obtaining excellent and reproducible results.

Results Total, fixed and immediate implant-prosthetic rehabilitation of completely edentulous jaws based on the "Roman Bridge Protocol" is a valid therapeutic alternative that can efficiently meet particular needs and expectations from patients.

KEYWORDS: All-on-4, implant-prosthetic rehabilitation, completely edentulous jaws, fixed implant prosthesis.

INTRODUCTION

In the last years, dental implantology has critically improved the care of complete edentulism. The rehabilitation of edentulous dental arches with total removable prosthesis in synthetic resin represents a valid treatment; however, the use of implants provides several practical, aesthetic and psychological advantages. Dental implants are important in stabilizing a removable prosthesis (overdenture) by the use of different retained tools, bar-retained implant-supported removable prosthesis or screw-retained/cemented implant-supported fixed prosthesis.

The advantage provided by an overdenture or a bar-retained implant-supported removable prosthesis consists in the stabilization of the prosthesis on the lower arch and elimination of the resin palate. The prosthesis can be removed by the patients. Instead, the use of screwed/cemented fixed prosthesis can restore a fixed dental arch without any intervention by the patients, since it has to be removed by the dentist.

However, the immediate post-extractive implants and the immediately-loaded implant prosthesis represent the first therapeutic option for those patients with long waits. The most important parameters that have to be considered in order to choose the right working plans are bone quality and quantity.

In case of severe bone atrophy, a pre-implant regenerative surgery is necessary and the immediately-loaded implant is contraindicated. The patient has to use a temporary total removable prosthesis (for 8-12 months) until the osseointegration is achieved. Thus, a crucial condition for a fixed immediately-loaded prosthesis is the presence of good quality native bone, in order to anchor a sufficient number of dental implants for the prosthetic rehabilitation. In 2003, Paul Malò introduced

1	Rough implants with external hexagon;
2	Implant lenght >= 13 mm;
3	Implant site under-preparation;
4	Torque insertion >= 40 Ncm;
5	Tilted distal implants (fifth and sixth molar zone) in the native bone;
6	Straight mesial implants (lateral zone/canines);
7	Pre-angled conical prosthetic pillars (e.g. universal angled stump, Low profile), from 0° to 30° degrees;
8	No osseo-regenerative techniques.

TABLE 1. Surgical step - Columbus Bridge protocol™.

a revolutionary technique named "All-on-4", which is characterized by the introduction of only four dental implants in the native bone of edentulous patients and, when possible, the application of an immediately-loaded total fixed screwed prosthesis, with reconstruction of soft tissues in pink resin, according to the Toronto Bridge protocol.1 The novelty of this technique consisted of positioning two straight implants (mesially) and two tilted implants (distally) in the native bone in front of the maxillary sinus, in the upper jaw, and in front of the mental nerve, in the lower jaw. In 2009, Tealdo and colleagues, together with Dr Paolo Pera from the University of Genoa, established the "Columbus Bridge Protocol", a surgical prosthetic protocol used for fixed screw-retained immediately-loaded implant-prosthetic rehabilitation in completely edentulous jaws.2
This protocol included a surgical step (Table 1) and a prosthetic step (Table 2).

METHODS AND MATERIALS

Our clinical technique consists of three different steps: diagnosis, surgery and prosthesis.
The diagnostic step (Table 3) is crucial for a correct planning of implant-prosthetic rehabilitation. It is worth stressing the importance of TC visualization programs, which give the possibility to evaluate measurements, angles and types of implants from different vendors. Most of the software can be a valid diagnostic tool for a good surgical planning. However, the clinician has always to take in consideration possible errors in the measurements. During surgery (Table 4), the anesthetist plays a very important role in order to achieve the best outcome, with the minimal stress conditions for the surgeon and post-surgical psychological traces for the patient. Deep sedation is done by intravenous administration of sedatives and major analgesics in doses and concentrations that can vary according to the health status, psychological condition, collaboration and awareness of the patient. The sedation will be modulated according to the surgery duration, in order to obtain a final pharmacological effect

1	Gypsum model by pick-up technique;
2	Total, fixed, screwed, temporal prosthesis;
3	Rigid stabilization by metal framework;
4	Passive fit with luting technique;
5	Acrylic occlusal surface;
6	No distal cantilever;
7	Functional occlusal loading.

TABLE 2. Prosthetic step - Columbus Bridge Protocol™

1.	Anamnesis;
2.	Physical examination;
3.	Dental molding for study models;
4.	Pictures;
5.	Orthopantomography;
6.	Computerized tomography dentascan or cone beam CT (CBCT);
7.	Possible virtual planning of the surgery by 3D software;
8.	Medical examinations (laboratory and instrumental tests);
9.	Cardiology and anesthesiology examinations;
10.	Meeting with the patient in order to understand his/her needs and expectations and, thus, to show him/her all the therapeutic options (that have to be evaluated again after radiology results and other diagnostic examinations).

TABLE 3. Clinical technique – Diagnostic step

1.	Deep consciousness sedation by intravenous administration;
2.	Bone flattening to regulate and shape the bone crest, initially through a large nose rongeur and later through a tungsten carbide bur (H251EQ 104 060, Komet Dental, Lemgo, Germany), assembled on a straight surgical handpiece, under continuous flow of cold physiological saline at 4°C;
3.	Conical implants;
4.	Implant diameter >= 3,8 mm;
5.	Implant length>= 12 mm (12 - 14 - 15,5 - 17 - 20 mm);
6.	Synthetic adsorbable string sutures 3-0 in polyglicolic acid (PGA).

TABLE 4. Clinical technique – surgical step.

also in the longer surgical cases of double dental arches, to avoid an excessive drug intake and to have a fast patient mobilization. Before the surgery, an alginate mold

of the antagonist arch has to be taken, together with records of vertical measurement, pictures and teeth color. Upon implant anchorage, prosthetic components have to be applied, that is the straight conical connections for the axial implants and the tilted conical ones (about 17° or 30°) for the tilted implants. These conical connections can have different diameters and transmucosal heights. Before the application of the tilted conical connections (17° or 30°), it would be helpful to use the manual or mechanical bone profiler. Upon the conical connection anchorage, a continuous suture has to be done with a synthetic, distal-mesial oriented absorbable string (e.g. polyglicolic acid 3-0), molding transfers are inserted and a gypsum model is taken by a pick-up technique.
Lastly, occlusal records are collected and cylinders are inserted as soft tissue conditioners. If the patient undergoes intravenous sedation, occlusal records can be taken in the operating room with a portable intra-oral scanner.
CAD/CAM technology has favored implant-supported restorations through a digital workflow. Optical intraoral scanner (IOS) has become one of the most valuable dental-treatment devices. IOS measures the surface shape of the target teeth or gums directly in the patient's mouth.
The intra-oral scanner emits a light beam (laser or structured light) towards the object to be digitized, the tip should be then moved along the arches and all anatomical structures will appear on the device's screen.
Dull, smooth and opaque surfaces are easier to capture than shiny, rough or translucent ones. It becomes challenging when saliva creates surface's reflection.
To capture the correct implant position, a specific transfer called an intra-oral scan body (ISB) must be used.
Reliable and accurate ISB design is crucial in edentulous areas because they are difficult to read for IOS due to lack of anatomic references.
ISBs are composed of three distinct parts: the scan region (corresponding to the upper portion), the body (corresponding to the middle portion) and the base (corresponding to the most apical portion that connects to the implant) (47). A mismatch between the base and the implant may influence the displacement of the ISB. It is necessary to create an ISB that can be efficiently interpreted by the IOS, easily employed by the operator and comfortable for the patient. The scan body should be fully visible in order to reduce errors. The deeper the implant is placed, the longer the scan body should be (47).
A complete digital workflow in the fabrication of fixed complete prosthetics is clinically precise and predictable. Full-arch digital implant scans are valid when tilted implants are present. IOS is a reliable method for definitive rehabilitation restorations with a successful and precis passive fit.
IOS has many advantages:

1. real-time impression scanning and visualization;
2. high reproducibility and quality;
3. reduction of cost and waste of materials;
4. simplicity and speed in replication.

1.	Gypsum mold with pick-up technique;
2.	Rigid stabilization with metal framework through electro welded grade 2 titanium bars;
3.	Occlusal surface made of composite PMMA (Poly(methyl methacrylate);
4.	Total, immediate, screw-retained implant prosthesis within 24 hours, with soft tissue reconstruction in pink and without distal cantilever;
5.	Removal of the "immediate" prosthesis after 4 months since the first application;
6.	Possible "definitive" implant prosthesis.

TABLE 5. Clinical technique – prosthetic step.

•	Electro welded grade 2 titanium bars;
•	Bars in PMMA (PoliMetilMetaAcrilato) (multiCOM, Bredent Medical, Selden, Germany), milled CAD/CAM;
•	Prefabricated, chair side or lab side manufactured bars SFI-Bar® (Cendres Metaux, Biel-Bienne, Switzerland).

TABLE 6. "Immediate" prosthetic internal frameworks.

The temperature and illumination of the room, the dentist's experience, the scanning technique affect the accuracy of the IOS readings. Patient's movements, limited mouth opening, and macroglossia may complicate the scanning procedure.
The patient is then dismissed without any dental prosthesis. A clear polysiloxane-based molding material (Fresh® clear, Dreve Dentamid, Unna, Germany) is applied on the wound and cylinders, which will be removed before the application of the immediate prosthesis (Table 5). A totally fixed screw-retained prosthesis (as for the "Toronto Bridge Protocol"), with any palate on the superior arch, will be manufactured and applied with an immediate-function within 24 hrs. This prosthesis is defined "immediate" and it may be a temporary (4 months), semi-definitive (medium/long-term period) or, for some patients, also a definitive prosthesis.
Some fundamental features of the immediate prosthesis are:

1. Rigid internal framework, in order to stabilize the four implants, to avoid micromovements and to promote their osseointegration;
2. Passive fit to the implants, to prevent tensions that can affect their osseointegration;
3. Soft occlusal surface of the dental elements, made in resin or composite (not in ceramic), to not over-load the implants and promote their osseointegration;
4. Reconstruction of the soft tissues in pink resin, since there is always a vertical bone reduction and it would prevent the unaesthetic "too long teeth";
5. Lack of distal cantilevers for the "angled" implants.

•	Fused cobalt-chrome bars;
•	Cobalt-chrome, titanium or zirconia bars, CAD/CAM milled;
•	Carbon fiber bars and glass fiber bars, CAD/CAM milled;
•	Bars in high performance polymers for restoration work on implants (thermoplastic polyaryletherketone family - PAEK), pressed and CAD/CAM milled:
•	BioHPP (Bredent Medical, Selden, Germany)
•	Pekkton® ivory (Cendres Metaux, Biel-Bienne, Switzerland)

TABLE 7. "Definitive" prosthetic internal frameworks.

All the materials that allow a rapid manufacturing, such as electro-welded grade 2 titanium bars (Welding Bridge), carbon or glass fibers, carbon fibre-reinforced composites (CFRC), pressed polymers (e.g. PEEK- acrylic resin) ("Colosseum Bridge"), milled composite CAD/CAM (e.g. PMMA) and lab side or chair side prefabricated metal (Table 6) are used for the reconstruction of the framework of the immediate prosthesis within 24hrs. They have to be prepared before the surgery. The passive fit, instead, may be obtained by luting the cylinders that will be used to screw the prosthesis on the conical bases.
The dental elements that will be used for the immediate prosthesis are commercially available prefabricated teeth. The immediate prosthesis is applied within 24 hrs and it will not be removed before 4 months.
Later, a new prosthesis will be made (definitive prosthesis), with some different features compared with the immediate prosthesis, such as:
- Rigid framework made of different materials;
- Commercial teeth or customized teeth made of composite or ceramic;
- Presence of distal cantilever for the "angled" implants, in order to obtain a prosthesis with twelve dental elements.

The framework for the "definitive" prosthesis can be done using materials as cobalt-chrome, titanium, zirconia, polymers or fiber (Table 7), which require a longer manufacturing procedure (such as melting, pressing or CAD/CAM milling).
In case of computer-guided surgery, it would be possible to use semi-worked fused or CAD/CAM milled rigid frameworks. They can be chair side completed, in order to reduce time delivery of the immediate prosthesis, so that the patient can be dismissed with the prosthesis already applied. In case of a torque insertion of implants shorter than 40 Ncm, a standard total removable immediate prosthesis is applied and the insertion of the "Toronto Bridge" will be postponed 3-4 months later. It is important to consider that may be more difficult for the prosthodontist to record the occlusal parameters related to a double arch compared with a single arch. The "All-on-4" technique is indicated for all those situations where the patient, who has a severe periodontal impairment and multiple dental caries, wants a fixed prosthetic rehabilitation in a short-time period.
The side effects of this technique can be:
- Severe: all those situations where the implant practice is discouraged (e.g. severe pathologies of the connective tissue, neoplasia, anatomic defects);
- Relatives: when the patient is receiving monoclonal antibody therapy (e.g. denosumab) or bisphosphonates for anti-neoplastic therapy; if he is suffering from bruxism or he is a great alcoholic, non-collaborative patients; subjects affected by severe neurologic pathologies or muscular dystrophy.

A Retrospective cohort study conducted by P. Malò et al. (35) highlights that there is no significant difference in the survival implant rate between smokers and nonsmokers. There is no absolute contraindication for rehabilitation of edentulous mandibles through the All-on-4 concept.
HIV-positive patients with a stable immune system can be candidates for the 'All-on-four' treatment concept (39). On the other hand, if the immune system is highly compromised relative complications may occur.
This implant-prosthetic technique has several advantages, as rapid execution, since potential dental extraction can be done during the same operation, implants can be inserted and molds for the prosthesis can be taken and produced within 24 hrs. Moreover, the patient is not particularly stressed since he does not remember anything about the surgery, which is conducted in conscious sedation (intravenous administration). The level of stress is minimized also for the surgeon, because the patient is sedated and does not offer resistance. Lastly, the functional and aesthetic results are good, with limited costs and rapid adaptation from the patient to the new stomatognathic and aesthetic layout.
However, there are also some disadvantages, due to the resistance from the patient to accept, from a psychological point of view, potential multiple dental extractions. In addition, if during the implant anchorage there are not the right conditions for an immediately-loaded prosthesis (insufficient torque, fenestrations, etc), it will be necessary to change for a delayed-loaded prosthesis, with the use of a standard temporal removable prosthesis. This possibility has to be clearly communicated to the patient before the operation. Sometimes the patient faces some difficulties carrying out the everyday oral hygiene at home. An important limit of this protocol is the execution itself, since the implant prosthetic technique has to be done by well-trained and skilled implantologist and prosthodontist. Another limit is the contraindication to the use of dental elements made of hard materials (ceramic, zirconia, etc) for the immediate prosthesis, which are often required by the patient for a better aesthetic outcome.

In addition, sometimes there is a difficult management of the smile line and prosthetic edges, since there will be always a vertical bone loss in the edentulous cases, where there is alveolar bone resorption, as well as in the edentulous made cases, since alveolar bone is removed during the bone flattening. The prosthodontist has to determine the right ratio between white area (dental size) and pink area (gingival size) of the prosthesis in order to obtain the best aesthetic result. The implant choice has to be done according to the best primary stability for a fixed immediately-loaded prosthesis. In our protocol, the implants are conformed as reported in Table 8. We have also included an element of implant flexibility that, based on our experience, can allow us to change the length of the implants according to the structural bone base available. If necessary, we can reduce the size of one or two fixtures, trying to use the longer size implants (15-17-18-20 mm tilted and 12-13-14-15 straight), without renouncing to the "All-on-4" prosthesis. The surgery equipment is reported in Table 9. About the surgical procedure, two cases have to be considered. The first situation is an arch with teeth and dental roots that has to be made edentulous, taking in consideration the therapeutic procedure described in Table 10. The second case is an already edentulous arch and the protocol has to be followed as described in Table 10, starting from point 2.

There are several technical tools that can be used by surgeons who are not so familiar with the "All-on-4" procedure, such as metal layer masks, used to set up the orientation of the distal angled implants, and the micro angle detector (I.D.I. Evolution Srl, Concorezzo, MB, Italy), which indicates the angulation (degrees) of the cutter during the implant surgery. In the "All-on-4" procedure, as in every surgical act, immediate or tardive post-operative complications can happen. In fact, edema, hematoma, pain, bleeding, iatrogenic lesions of sensitive structures (maxillary sinus, inferior alveolar neurovascular bundle, mental nerve, vessels, etc.) can arise immediately. On the other hand, potential infections, bone sequestrum and mucosal dehiscences may develop in a second moment. This technique may also lead to mechanical and/or biological failures, when, for example, the prosthesis does not show passive fit on the implants and there is not a good distribution of the chewing strengths. The resulting occlusal over-loaded can cause the loss of one or two implants. This situation may happen also in case of bacterial contamination of the bone bases or surrounding mucosa.

Digital workflow for computer implant surgery is a modern clinical procedure, that allows less invasive surgeries, implant placement, reduction of postoperative discomfort and production of prosthesis before surgery that fits correctly. Through CBCT and oral optical scanner, 3D data is obtained and then processed by an implant planning software that allows to realize the surgical and prosthetic design. There are several steps to follow in order to achieve a 3-dimensional virtual plan and simulate surgical phases, that will be shifted into the patient's mouth by the surgical guide and protocol.

Hämmerle et al. (33) delineate guided surgery as a static guide that reproduces the virtual position of the implant to allow intraoperative real-time tracking of the drills according to the planned trajectory.

CBCT scans and intraoral optical scan impressions must be taken and then aligned to each other before implant planning. The data of intraoral optical scans are available in the STL format, whilst CBCT in DICOM format. After data import, the ideal position of implant-supported prosthesis is planned. The abutment design with its emergence profile, morphology of the tooth, occlusal and proximal contacts but be studied (46). The placement of the implants must be in prosthodontically driven positions compatibly with the bony anatomy. Once, both surgical and prosthetic design are done, surgical guides will be manufactured. Surgical guides can be tooth, bone or mucosa supported, with or without stabilization pins. The surgical guide has holes that guide the drills in preparing the implant site and inserting the implant. Cassetta et al. (33) evaluated the

1.	self-threading;
2.	conical;
3.	spirals;
4.	width >= 3,8 mm;
5.	lenght >= 12 mm;
6.	treated surface (rough), preferentially nanostructured type;
7.	Machined implant neck (compatible with selected implant).

TABLE 8. Dental implant choice.

1.	Local anesthetic (articaine/lidocaine);

TABLE 9. Surgical armamentarium.

1.	Total recovery;
2.	Incision of gingival strips;
3.	Indentification of mandibular sinus and mental nerves;
4.	Bone flattening;
5.	Implant insertion;
6.	Conical base allocation;
7.	Mold transfer allocation;
8.	Suture;
9.	Mold collection;
10.	Temporal recovery cylinders allocation

TABLE 10. Surgical prosthetic procedure.

precision of muco-supported surgical guides with and without fixation screws in the edentulous ridges. They demonstrated that fixed guides provide precise implant placement, reducing errors between the planned and the executed treatment, and greater trans-operative stability.
Before procedure, the surgical guide is fitted in the oral cavity and must be precisely adapted on mucosa or teeth, depending on which support has been chosen.
The advantages of a virtual programming software are:

1. Decision of implant sites according to bone volume and quality;
2. respect of noble anatomical structures (es. Inferior alveolar nerve);
3. predetermination of prosthesis path of insertion and
4. pre-fabrication of individual abutments.

For the all-on-four surgical technique this new technological approach allows mini-invasive flapless surgeries and a pre-surgical fabricated fixed prosthesis, in order to achieve a functional and aesthetic immediate loading. In addition, guided surgery could sometimes avoid bone augmentation procedures even in post-extractive implants in atrophic areas, allowing immediate loading. Fortin reported 98% implant survival rate, without inflammation and infection, after 4 years in partially edentulous cases with severely resorbed posterior maxilla avoiding sinus augmentation procedure (32). Ideal implant placement attests excellent esthetic and prosthetic outcomes.
The inappropriate positioning of the implant would lead to (45):

1. erroneous occlusion with ATM disorders;
2. improper oral hygiene which could cause peri-implantitis and
3. lack of peri-implant health due to mechanical trauma.

All these aspects contribute to implant's loss at an early stage.
Guided implant surgery can be static and dynamic. In the dynamic guided surgery all phases are performed directly by the surgeon who will work freehand, guided by a system of optical sensors capable of reading the position of the drills in relation to the predetermined position of the implant on the CT scan. Therefore, there is no more a surgical guide as the static approach. We prefer and have used the static guided surgery, but which technique is better will not be discussed in this article.
Computer implant surgery is accurate and reliable compared with free-handed implant surgery(40). The surgery is more predictable, less stressful and operation time is reduced. However, deviation between implant virtual plan and implant real position could be due to errors throughout the digital workflow. Economic aspects must also be evaluated regarding formation, instrumentation, surgical templates realization (40).
However, the installation of the surgical stent can slow down the execution. In addition, the spatial planning, even if perfect, does not consider unexpected changes, it cannot be used in patients with a bad mouth opening, costs are remarkable and it confers to the surgeon a false sense of confidence. For this reason, a not well-trained operator is incline to adopt this technical approach, which has many advantages, but also several limits. Thus, it is always preferred that only the operators with a good competence and surgical experience opt for this procedure.

Clinical case reports

A 56 years old patient, male, came to our dental practice for a full arch rehabilitation of the upper dental arch (Fig. 1,2). He showed clinical, aesthetic and time expectations. He underwent seven dental extractions and four immediate post-extractive implants with the insertion of an immediately-loaded Toronto Bridge.
A 70 years old patient, male, came to our dental practice for a full arch rehabilitation of the lower dental arch (Fig. 3,4). He showed functional and time expectations. He underwent eight dental extractions and four immediate post-extractive implants with the insertion of an immediately-loaded Toronto Bridge (with an internal framework made of fused cobalt-chrome).
A 49 years old patient, female, came to our dental practice for a full arch rehabilitation of both dental arches. (Fig. 5,6,7). She showed clinical, functional, aesthetic, time and emotional expectations, since she was odontophobic, with a severe periodontitis, bad oral hygiene and multiple dental caries. She was a heavy smoker. She underwent eighteen dental extractions and eight immediate post-extractive implants during a single appointment, with the application of a double immediately-loaded Toronto Bridge.
A 78 years old patient, female, came to our dental practice for a full arch rehabilitation of the upper dental arch (Fig. 8,9). She showed functional and time expectations. She underwent six dental extractions and four immediate post-extractive implants with the insertion of an immediately-loaded Toronto Bridge.
A 81 years old patient, female, came to our dental practice for a full arch rehabilitation of the lower dental arch (Fig. 10,11). She showed clinical, functional and time expectations, with a severe periodontitis, bad oral hygiene and dental mobility. She underwent nine dental extractions and four immediate post-extractive implants with the application of a temporary total removable prosthesis due to an insufficient insertion torque. A definitive Toronto Bridge was applied 3 months later.
A 70 years old patient, female, came to our dental practice for a full arch rehabilitation of both dental arches (Fig. 12,13,14). She showed clinical, aesthetic, functional and time expectations, with a severe periodontitis, bad oral hygiene and dental mobility. She underwent four-

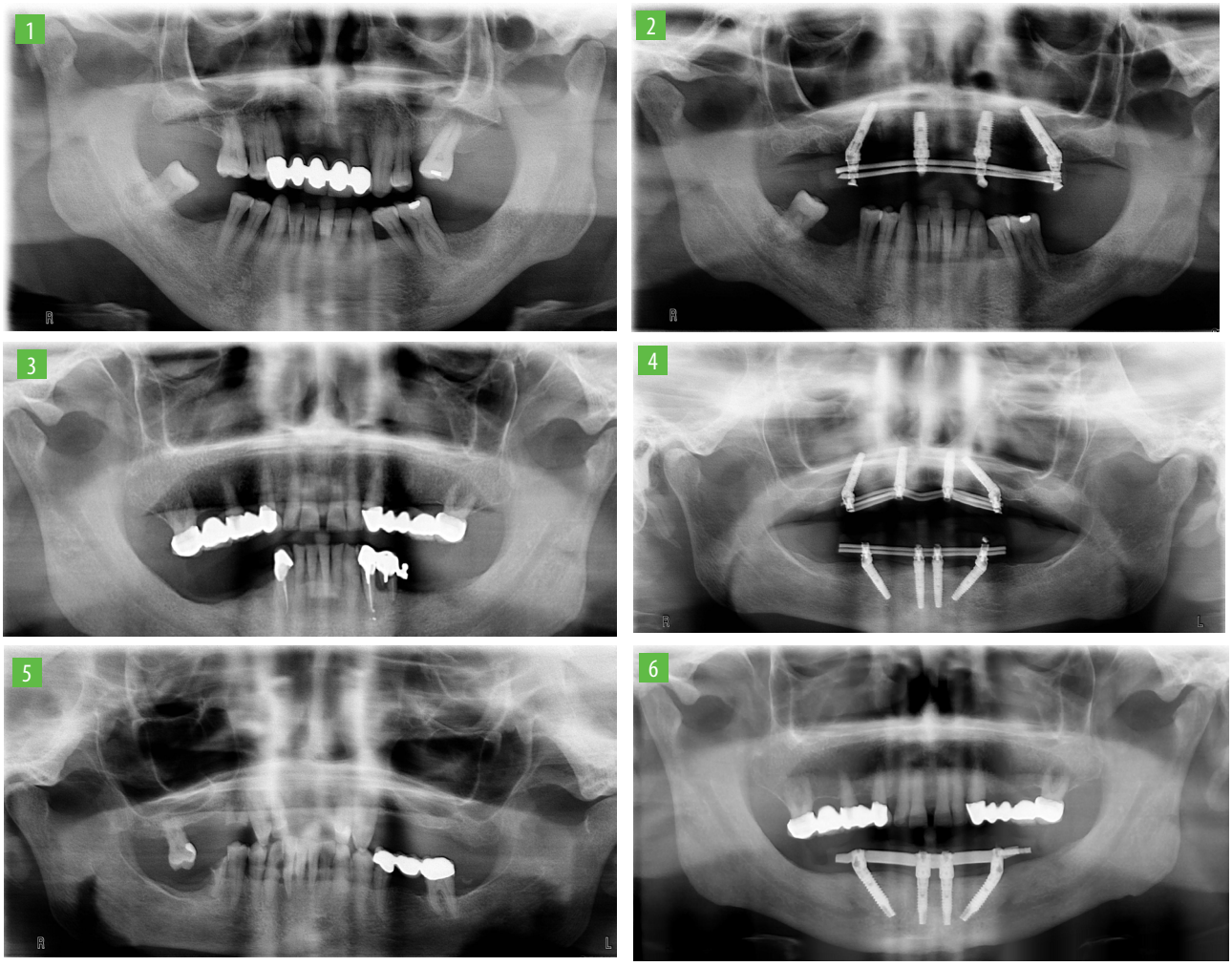
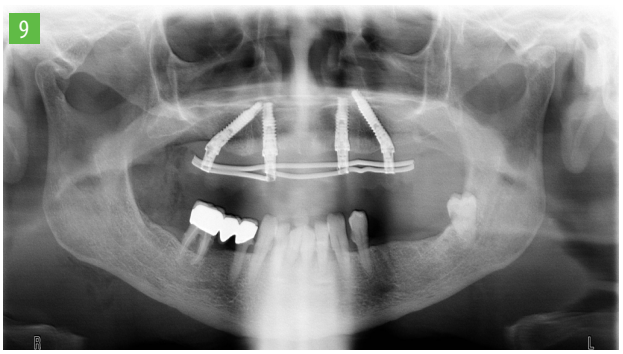
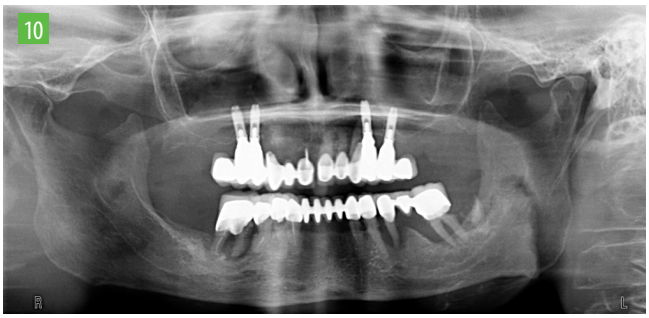
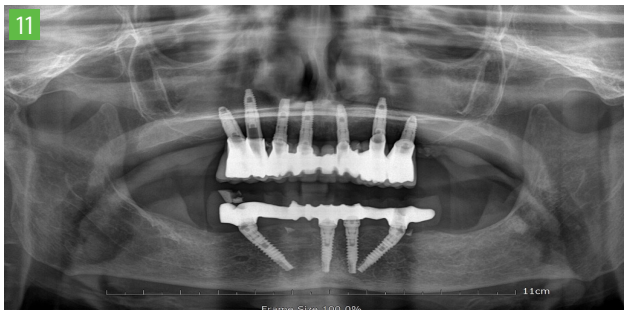


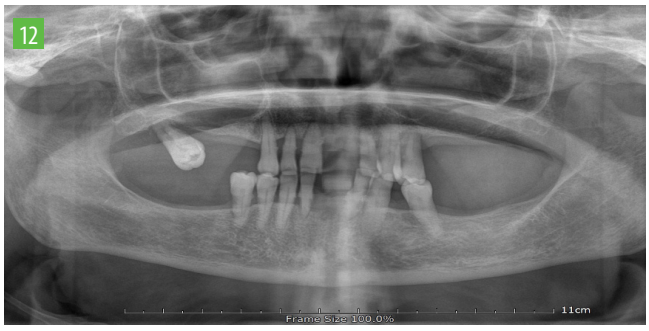
FIG. 1 Pre op x-ray. 56 years old man clinical case.
FIG. 2 Post op x-ray. Multiple dental extractions (seven) in the upper arch. Four dental immediate post-extractive implants: two axial implants (4,3x12 mm; I.D.I. Evolution Srl, Concorezzo, MB, Italy) and two tilted implants (4,3x17 mm - 3,75x17 mm; I.D.I. Evolution Srl, Concorezzo, MB, Italy). Internal framework with welded grade 2 titanium bars.
FIG. 3 Pre op x-ray. 70 years old man clinical case.
FIG. 4 Post op x-ray. Multiple dental extractions (eight) in the lower arch. Four dental immediate post extractive implants: two axial implants (3,80x15 mm; Sweden & Martina Spa, Due Carrare, PD, Italy) and two tilted implants (4,25x18 mm; Sweden & Martina Spa, Due Carrare, PD, Italy). Internal framework with fused metal.
FIG. 5 Pre op x-ray. 49 years old woman clinical case.
FIG. 6 Post op x-ray. Multiple dental extractions (eighteen) in the upper and lower arches. Double full arch rehabilitation. In the upper arch, four dental immediate post-extractive implants: two axial implants (4,0x13 mm; Biomet 3i™, USA) and two tilted im-plants (4,0x15 mm; Biomet 3i™). In the lower arch, four dental immediate post-extractive implants: two axial implants (4,0x15 mm; Biomet 3i™) and two tilted implants (4,0x15 mm; Biomet 3i™, USA). Internal framework with welded grade 2 titanium bars.

FIG. 7 Screwed fixed immediate double full arch rehabilitation (Toronto Bridge).









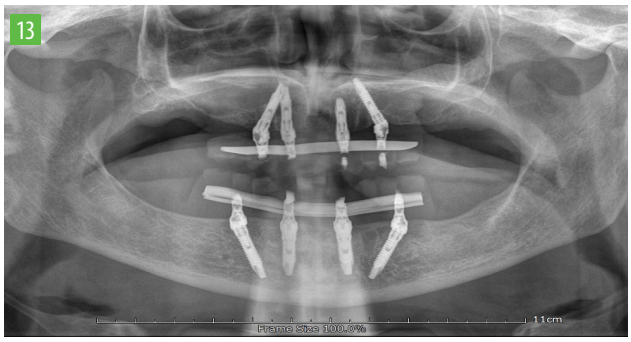


FIG. 8 Pre op x-ray. 78 years old woman clinical case.

FIG. 9 Post op x-ray. Multiple dental extractions (six) in the upper arch. Four dental immediate post extractive implants: two axial implants (4,25x13 mm; Sweden & Martina Spa, Due Carrare, PD, Italy) and two tilted implants (4,25x18 mm; Sweden & Martina Spa, Due Carrare, PD, Italy). Internal framework with welded grade 2 titanium bars.

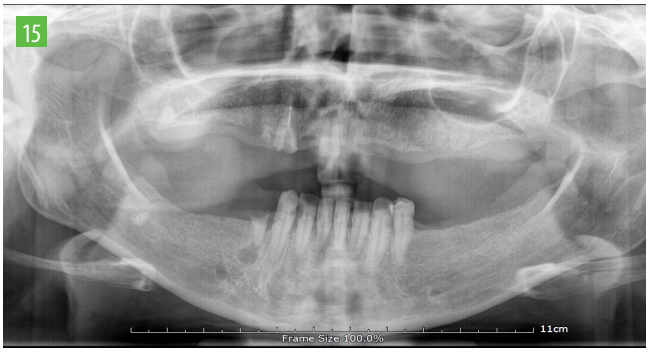
FIG. 10 Pre op x-ray. 81 years old woman clinical case.

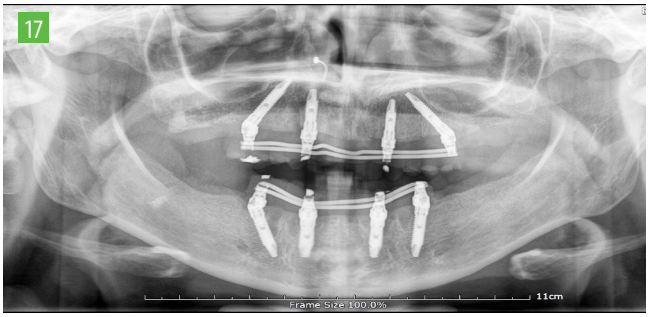
FIG. 11 Post op x-ray. Multiple dental extractions (nine) in the lower arch. Four dental immediate post extractive implants: two axial implants (3,80x15 mm; Sweden & Martina Spa, Due Carrare, PD, Italy) and two tilted implants (3,80x15 mm; Sweden & Martina Spa, Due Carrare, PD, Italy). Internal framework with fused metal. Later on, multiple dental extractions (four) and four explants in the upper arch. Seven delayed implants and porcelain fused to metal full arch rehabilitation.

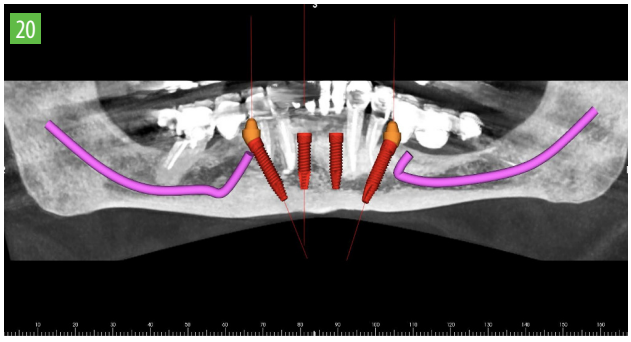
FIG. 12 Pre op x-ray. 70 years old woman clinical case.

FIG. 13 Post op x-ray. Multiple dental extractions (fourteen) in the upper and lower arch. Double full arch rehabilitation. In the upper arch, four dental immediate post-extractive implants: two axial implants (3,8x14 – 3,8-12 mm; I.D.I. Evolution Srl, Concorezzo, MB, Italy) and two tilted implants (3,8x17mm; I.D.I. Evolution Srl, Concorezzo, MB, Italy). In the lower arch, four dental immediate post-extractive implants: two axial implants (3,8x14 mm; I.D.I. Evolution Srl, Concorezzo, MB, Italy) and two tilted implants (3,8x17mm; I.D.I. Evolution Srl, Concorezzo, MB, Italy). Internal framework with welded grade titanium bar.

FIG. 14 Screwed fixed immediate double full arch rehabilitation (Toronto Bridge).







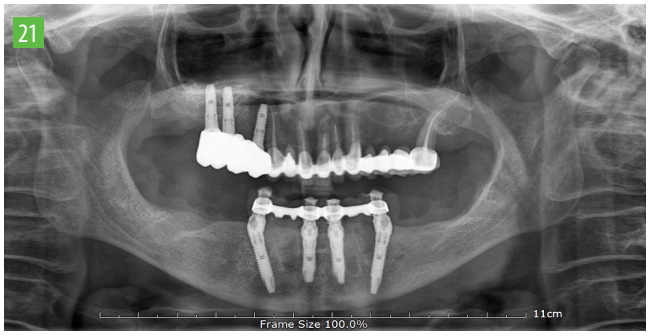
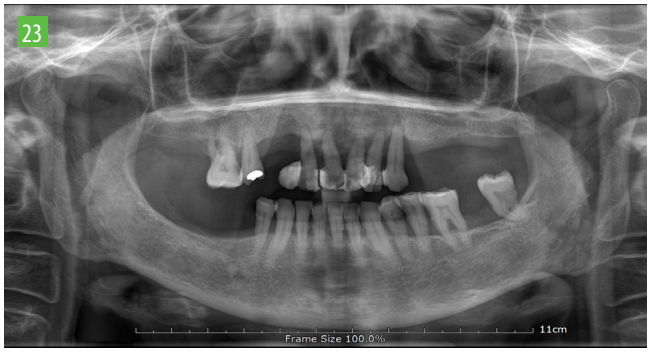
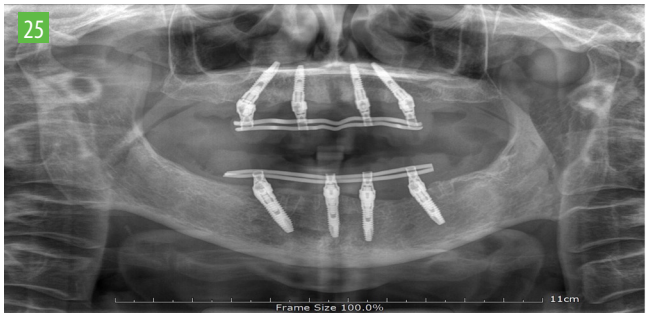
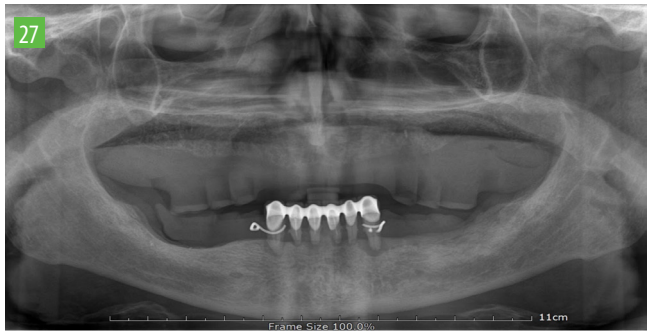
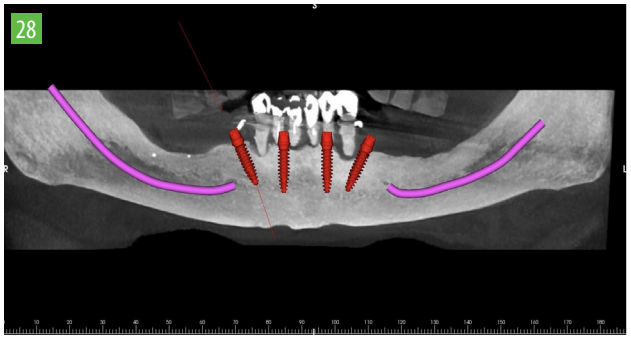


FIG. 15 Pre op x-ray. 38 years old woman clinical case.
FIG. 16 Pre photo.
FIG. 17 Post op x-ray. Multiple dental extractions (ten) in the upper and lower arch. Double full arch rehabilitation. In the upper arch, four dental immediate post-extractive implants: two axial implants (3,8x14 mm; I.D.I. Evolution Srl, Concorezzo, MB, Italy) and two tilted implants (3,8x17 mm; I.D.I. Evolution Srl, Concorezzo, MB, Italy). In the lower arch, four dental immediate post-extractive implants: two axial implants (3,8x14 mm; I.D.I. Evolution Srl, Concorezzo, MB, Italy) and two tilted implants (3,8x17 mm; I.D.I. Evolution Srl, Concorezzo, MB, Italy). Internal framework with welded grade 2 titanium bars.
FIG. 18 Screwed fixed immediate double full arch rehabilitation (Toronto Bridge).
FIG. 19 Pre op x-ray. 78 years old woman clinical case.
FIG. 20 Implant project on digital software (RealGUIDETM 5.0 PRO, 3DIEMME Srl, Cantù, CO, Italy).
FIG. 21 Post op x-ray. Multiple dental extractions (seven) in the lower arch. Four dental immediate post extractive implants in static computer guided surgery: two axial implants (3,8x14 mm; I.D.I. Evolution Srl, Concorezzo, MB, Italy) and two tilted implants (3,8x17 mm; I.D.I. Evolution Srl, Concorezzo, MB, Italy). Internal framework with milled metal. Later on, one dental extractions in the upper arch. Sinus lift with three delayed implants after an eight months period and zirconia partial fixed bridge.
FIG. 22 Screwed fixed immediate double full arch rehabilitation (Toronto Bridge).









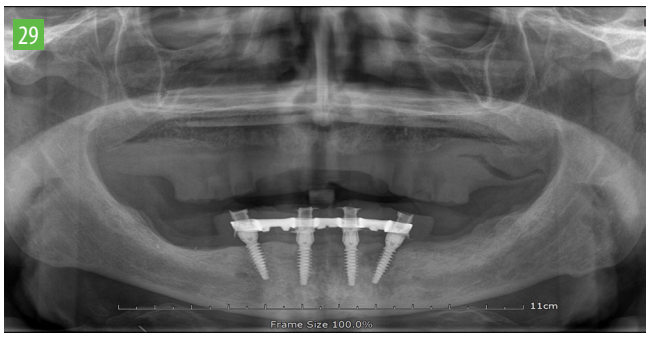
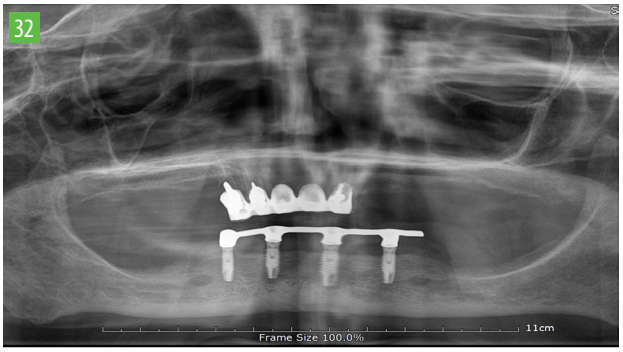
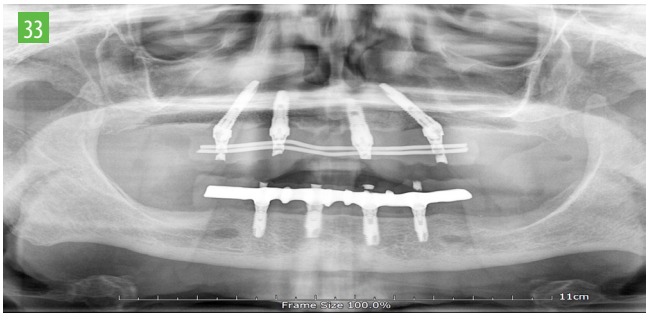


FIG. 23 Pre op x-ray. 54 years old woman clinical case.
FIG. 24 Pre photo.
FIG. 25 Post op x-ray. Multiple dental extractions (eighteen) in the upper and lower arch. Double full arch rehabilitation. In the upper arch, four dental immediate post-extractive implants: two axial implants (3,8x12mm; I.D.I. Evolution Srl, Concorezzo, MB, Italy) and two tilted implants (3,8x15,5 mm - 3,8x14 mm; I.D.I. Evolution Srl, Concorezzo, MB, Italy). In the lower arch, four dental immediate post-extractive implants: two axial implants (3,8x12 mm; I.D.I. Evolution Srl, Concorezzo, MB, Italy) and two tilted implants (3,8x14 mm – 4,3x12 mm; I.D.I. Evolution Srl, Concorezzo, MB, Italy). Internal framework with welded grade 2 titanium bars.
FIG. 26 Screwed fixed immediate double full arch rehabilitation (Toronto Bridge).
FIG. 27 Pre op x-ray. 60 years old man clinical case.
FIG. 28 Implant project on digital software (RealGUIDETM 5.0 PRO, 3DIEMME Srl, Cantù, CO, Italy).
FIG. 29 Post op x-ray. Multiple dental extractions (six) in the lower arch. Four dental immediate post extractive implants with static computer guided surgery: two axial implants (3,7x14 mm; I.D.I. Evolution Srl, Concorezzo, MB, Italy) and two tilted implants (3,7x14 mm; I.D.I. Evolution Srl, Concorezzo, MB, Italy). In Internal framework with milled metal.
FIG. 30 Screwed fixed immediate double full arch rehabilitation (Toronto Bridge).





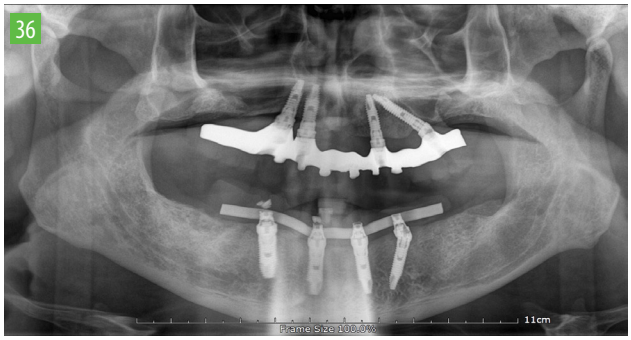
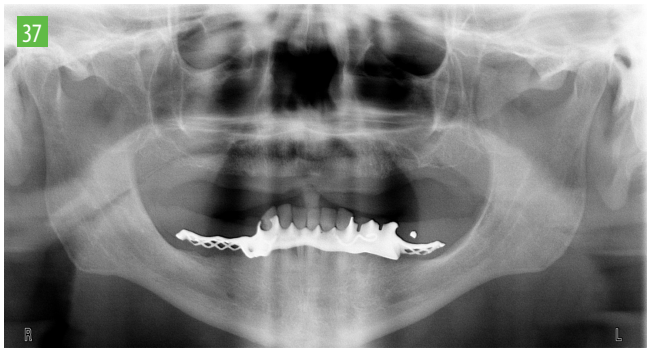
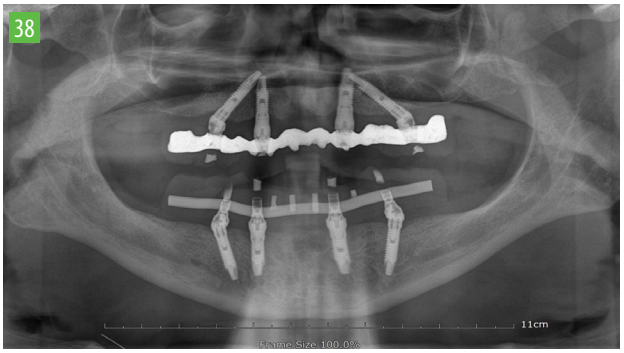


FIG. 31 Pre op x-ray. 80 years old woman clinical case.
FIG. 32 Post op x-ray. Multiple dental extractions (five) in the upper arch. Four dental immediate post-extractive implants: two axial implants (3,8x14 mm; I.D.I. Evolution Srl, Concorezzo, MB, Italy) and two tilted implants (3,8x17 mm I.D.I. Evolution Srl, Concorezzo, MB, Italy). Internal framework with welded grade 2 titanium bars. Later on, a new rehabilitation with internal framework with fused metal in the lower arch.
FIG. 33 Screwed fixed immediate upper arch rehabilitation.
FIG. 34 Pre op x-ray. 65 years old man clinical case.
FIG. 35 Post op x-ray. Multiple dental extractions (twenty) in the upper and lower arch. Double full arch rehabilitation. In the upper arch, four dental immediate post-extractive implants: two axial implants (3,8x14mm; I.D.I. Evolution Srl, Concorezzo, MB, Italy) and two tilted implants (3,8x12 mm - 3,8x17 mm; I.D.I. Evolution Srl, Concorezzo, MB, Italy). In the lower arch, four dental immediate post-extractive implants: two axial implants (3,8x15 mm; I.D.I. Evolution Srl, Concorezzo, MB, Italy) and two tilted implants (4,3x14 mm - 3,8x17 mm; I.D.I. Evolution Srl, Concorezzo, MB, Italy). Internal framework with welded grade titanium bar in the lower arch and internal framework with fused metal in the upper arch.
FIG. 36 Screwed fixed immediate double full arch rehabilitation.

teen dental extractions and eight immediate post-extractive implants during a single appointment, with the application of a double immediately-loaded Toronto Bridge.
A 38 years old patient, female, came to our dental practice for a full arch rehabilitation of both dental arches (Fig. 15, 16, 17, 18). She showed clinical, aesthetic, functional and time expectations, with a severe periodontitis, bad oral hygiene, missing teeth and dental mobility. She underwent ten dental extractions and eight immediate post-extractive implants during a single appointment, with the application of a double immediately-loaded Toronto Bridge.
A 78 years old patient, female, came to our dental practice for a full arch rehabilitation of the lower dental arch (Fig. 19, 20, 21, 22). She showed functional and time expectations. She underwent seven dental extractions and four immediate post-extractive implants with a surgical guide during a single appointment, with the application of an immediately-loaded Toronto Bridge. Later on, one dental extraction in the upper arch have been done. Sinus lift with three delayed implants after an eight-month period and zirconia partial fixed bridge have been carried out.





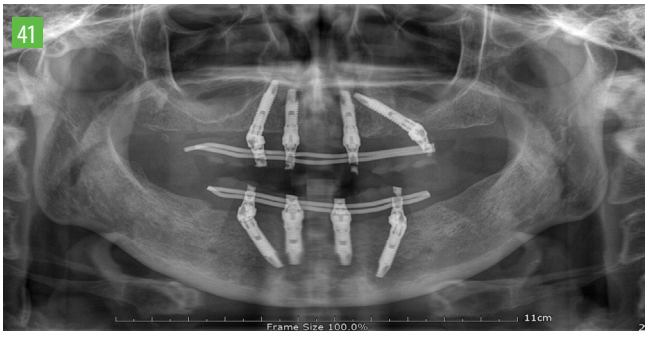


FIG. 37 Pre op x-ray. 64 years old man clinical case.
FIG. 38 Post op x-ray. Multiple dental extractions (seven) in the upper and lower arch. Double full arch rehabilitation. In the upper arch, four dental immediate post-extractive implants: two axial implants (3,8x14 mm; I.D.I. Evolution Srl, Concorezzo, MB, Italy) and two tilted implants (3,8x17 mm; I.D.I. Evolution Srl, Concorezzo, MB, Italy). In the lower arch, four dental immediate post-extractive implants: two axial implants (3,8x14 mm; I.D.I. Evolution Srl, Concorezzo, MB, Italy) and two tilted implants (3,8x17 mm I.D.I. Evolution Srl, Concorezzo, MB, Italy). Internal framework with welded grade titanium bar in the lower arch and internal framework with fused metal in the upper arch.
FIG. 39 Screwed fixed immediate double full arch rehabilitation (Toronto Bridge).
FIG. 40 Pre photo. 68 years old woman clinical case.
FIG. 41 Post op x-ray. Post op x-ray. Multiple dental extractions (twenty) in the upper and lower arch. Double full arch rehabilitation. In the upper arch, four dental immediate post-extractive implants: two axial implants (3,8x14 mm; I.D.I. Evolution Srl, Concorezzo, MB, Italy) and two tilted implants (3,8x17 mm; I.D.I. Evolution Srl, Concorezzo, MB, Italy). In the lower arch, four dental immediate post-extractive implants: two axial implants (3,8x14 mm; I.D.I. Evolution Srl, Concorezzo, MB, Italy) and two tilted implants (3,8x17 mm; I.D.I. Evolution Srl, Concorezzo, MB, Italy). Internal framework with welded grade 2 titanium bars.
FIG. 42 Screwed fixed immediate double full arch rehabilitation (Toronto Bridge).

A 54 years old patient, female, came to our dental practice for a full arch rehabilitation of both dental arches (Fig. 23, 24, 25, 26). She showed clinical, aesthetic, functional and time expectations, with a severe periodontitis, bad oral hygiene, missing teeth, multiple caries and dental mobility. She underwent eighteen dental extractions and eight immediate post-extractive implants during a single appointment, with the application of a double immediately-loaded Toronto Bridge.

A 60 years old patient, male, came to our dental practice for a full arch rehabilitation of the lower dental arch (Fig. 27, 28, 29, 30). He showed functional and aesthetic expectations. He underwent six dental extractions and four immediate post-extractive implants with a surgical guide during a single appointment, with the application of an immediately-loaded Toronto Bridge

A 80 years old patient, female, came to our dental practice for a full arch rehabilitation of the upper dental arch (Fig. 31, 32, 33). She showed functional, aesthetic and time expectations. She underwent five dental ex-

tractions and four immediate post-extractive implants with during a single appointment, with the application of an immediately-loaded Toronto Bridge.
A 65 years old patient, male, came to our dental practice for a full arch rehabilitation of both dental arches (Fig. 34, 35, 36). He showed clinical, aesthetic, functional and time expectations, with periodontitis, bad oral hygiene and dental mobility. He underwent twenty dental extractions and eight immediate post-extractive implants during a single appointment, with the application of a double immediately-loaded Toronto Bridge.
A 64 years old patient, male, came to our dental practice for a full arch rehabilitation of both dental arches (Fig. 37, 38, 39). He showed aesthetic, functional and time expectations, with an upper total mobile prosthesis and a lower partial mobile prosthesis. He underwent seven dental extractions and eight immediate post-extractive implants during a single appointment, with the application of a double immediately-loaded Toronto Bridge.
A 68 years old patient, female, came to our dental practice for a full arch rehabilitation of both dental arches (Fig. 40, 41, 42). She showed clinical, aesthetic, functional and time expectations, with a severe periodontitis, bad oral hygiene, multiple dental caries and dental mobility. She underwent twenty dental extractions and eight immediate post-extractive implants during a single appointment, with the application of a double immediately-loaded Toronto Bridge.

DISCUSSION

In 2003, Malò published his first paper about the "All-on-4" technique, describing a 1-year retrospective study where he treated completely edentulous mandibles using a Brånemark System Implants and reporting an extraordinary survival rate of the implants (98.2%)(1). He also obtained very convincing results on completely edentulous maxillae, with a comparable survival rate of the implants (97.6%), highlighting the extraordinary efficacy of the "All-on-4" protocol on both jaws(3). In this technique, the surface treated dental implants seemed to be more efficient compared with the machined ones(4). The "All-on-4" was a valid technique also when a flapless computer-guided surgery on both arches was used(5,6). Lopes and colleagues reported a survival rate of the implants of 96.6% in 5 years(7). In a 5-year retrospective study on patients affected by periodontitis, it was reported a lower survival rate of the implants (91%) compared with the healthy patients(8). However, in a retrospective study on patients affected by non-treated periodontitis before the surgical therapy, the survival rate of the immediately-loaded implants was excellent (99.4%), when the implant-prosthetic conservation was good(9). Agliardi and colleagues reported a successful use of two straight and two tilted immediately-loaded implants(10). In addition, there was no significant difference about the survival rate of implants inserted on the maxillary bones, both axials and tilted ones(11). It was also observed that stress generated around the peri-implant bone is lower in tilted implants without distal cantilever compared with axial implants with distal cantilever(12,13). A pilot study of 12 years from Tealdo and colleagues reported a survival rate of 92.8% of the implants on completely edentulous maxillae(14). In addition, in both 3 year- and 6-year-retrospective studies, he observed no differences about the survival rate of the immediately or postponed-loaded implants, and that loss of marginal bone was always lower when the immediately-loaded implant was used(15,16). In a 6-year-prospective study on completely edentulous maxillae using the "Columbus Bridge Protocol", a failure of 4 implants out of 164 was reported during the first 6 months (2.4%)(17). Malò and colleagues published a 10-year-longitudinal study on completely edentulous mandibles with a survival rate of 94.8% for the implants and 99.2% for the prosthesis(18). Similar results were obtained in a 5-year study on completely edentulous maxillae (survival rate of 98% for the implants, 100% for the prosthesis)(19). These data showed the reliability of this technique also in the medium-long term period. The "All-on-4" technique can be used with good results also when more than four implants were used in the medium-term period on maxillae with different degree of bone reabsorption(20). It resulted to be valid also for a short-term period on both jaws, in critical clinical conditions, such as immediate post-extractive implants, patients affected by periodontitis and bad bone quality and quantity (fenestrations and dehiscences)(21). In 2014, Malò and colleagues described a clinical report about a successful short-term follow-up with prosthesis made of lithium disilicate, in the upper arch, and resin, in the lower arch, supported by four implants for each arch(22). They also reported that implants 20-25 mm in length with bicortical anchorage on bad quality bone were efficient(23). In a 5-year retrospective study, no differences were observed in the survival rate of the implants between a double full arch rehabilitation (upper and lower arch) and a single immediately-loaded full arch, except for some mechanical complications in the second case(24). A survival rate of 95.4 % was reported in a 7-year-retrospective study on fully edentulous mandibles, where the most important risk factors were smoke and the learning curve effect(25). A clear improvement of gastric processes was noted upon immediate-loading full arch rehabilitation(26). In a 3-year-retrospective study on fully edentulous maxillae, the survival rate of the implants was 95,7% using short implants, 100% with regular implants and 96.6% with the longer ones(27). Thus, the use of short implants seems to be acceptable, even if it has to be confirmed in long-term studies. The employment of rigid metal framework is the best solution for a full arch implant prosthesis and the luting technique is the more convenient option for the passive fit of the prosthesis on the implants(28,29). Recently, an addi-

tional 5-year-retrospective study on both fully edentulous mandibles and maxillae was described, with a survival rate of the implants of 97.3%(30).

CONCLUSION

Starting from 2003, we have attended to the birth and the evolution of "All-on-4" technique. Our personal experience, taking in consideration the state of art and several experienced techniques, led us to elaborate and integrate a complete diagnostic, surgical and prosthetic protocol, which is reproducible in every day dental practice, named "Roman Bridge Protocol". Our protocol is characterized by a well-structured diagnostic phase, a detailed working plan, use of intravenous sedation, flexibility about the size (length and caliber) of the immediate post-extractive implants to use and codification of the internal framework of the immediate and definitive prosthesis. However, even if this technique offers several professional and personal satisfactions, it is always necessary to improve the operational experience, as well as to ameliorate our scientific knowledge by elaborating all the data coming from the literature.

Clinical significance

The total fixed immediately-loaded implant-prosthetic rehabilitation of completely edentulous jaws, without the insertion of bone grafts, according to the "Roman Bridge Protocol", represents a valid therapeutic option for several patients with particular needs. Their clinical, functional, aesthetic, time, emotional and economic expectations can be completely satisfy by the use of a complex technique, which guarantees highly predictable results.

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Conflicts of interest

Nothing to declare.

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