Implant repositioning with segmental osteotomy

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Title page:

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Keywords:

- Implants
- Pre-implant surgery
- Bone graft
- Reconstruction

Summary

Introduction: The aim of this study is to assess a pioneering technique for atrophic premaxilla restoration. The objective is to reposition an implant reconstruction zone into a position both anatomically and physiologically suitable for occlusal function. Indeed, unlike the other few articles published on the correctional osteotomy of the implant in an inadequate situation, we have planned here an initially « unsuitable » insertion in order to benefit of the available bone mass.

Material and method: 3 patients aged 14 to 20 years old (1 woman and 2 men) were operated on at the maxillo-facial department of Lille 2 University Hospital for partial implant-prosthetic rehabilitation on atrophic maxillary and/or mandibular sector.

13 implants were seated (85% in the maxilla) in the native bone then moved subsequently by segmental osteotomy.

Results: The patients were assessed both clinically and radiologically according to the functional and aesthetic criteria of implant-prosthetic restoration.

Functionally, a biomechanically favourable implant/number of teeth ratio (80%) was achieved, with consistent occlusal relationships (centric positioning of the midline point and absence of crossbite) in 100% of cases. Aesthetically, the screw access hole is systematically non-apparent (100%) but has a prosthetically substituted reduced gingivo-alveolar architecture.

Discussion: These observations suggest that implant repositioning with segmental osteotomy allows for atrophic premaxilla restoration in implanted bone volume whatever the initial angulation.

Peri-implant aesthetic difficulties are not specific to the technique suggested here but are quite common to all premaxilla reconstruction techniques.

Lastly, this group of three patients is not enough to be conclusive, and a larger group would be necessary to validate this type of management.

Text:

Introduction:

Nowadays, edentulous sector reconstruction is a real challenge when several dimensions need reconstruction. Managing the premaxilla sector is still more complex, as indicated by the large number of publications on the topic. (1–3)

There is currently no consensus regarding the gold standard technique but autologous bone remains the reference material (4). Autografts represent a gold standard for bone reconstruction with a potential for osteogenics, osteoinduction, and osteoconduction (5), on another hand, bone substitutes with osteoconductive scaffold properties are available for clinical applications (6). Nevertheless, muscular pressure and soft tissue functions, broadly speaking, favour the graft or bone substitute resorption on the defect site that may reach up to 90% (7) and vary with donor sites or with the bone substitute used. This condition is particularly encountered in the management of premaxillary edentulous sector, mostly in traumatic and multi-operated sites where it leads to non-functional or unaesthetic results.

Indeed, unlike the other few articles published (8–10) on the correctional osteotomy of the implant in an inadequate situation, we have planned here an initially « unsuitable » insertion in order to benefit of the available bone mass.

The aim of our study was to evaluate through three clinical cases, an innovative approach consisting of displacement of the reconstructed zone to an area with reduced resorption risks while preserving the implant emergence profile.

Patients and Methods:

Patients

We retrospectively enrolled patients undergoing the following innovative treatment plan. The surgical technique was not specific and relied on the same principles as alveolar-dental osteotomy performed in the context of orthognathic surgery.

Implant repositioning segmental osteotomy protocol

Implant placement was carried out four months before the segmental osteotomy technique to obtain a satisfactory osseointegration. It is carried out without taking into account either the positioning or the optimal angulation in relation to the functional objectives and aesthetic requirements of the implant-prosthetic project. Moreover, to allow consistency in the repositioning of the implants, it is preferable that implant axes are parallel to each other.

Implant repositioning segmental osteotomy was then preformed as follows (Fig. 1):

- Local infiltration of articaine hydrochloride with 1/200,000 adrenaline
- Mucous approach: Le Fort I incision of the whole superior maxillary surface allowing for facial and palatal fibromucous attachment preservation
- Le Fort I osteotomy according to the standard technique with segmentation of the bone-implant area
- Occlusion of the displaced anterior sector on implant-supported prostheses
- Graft stabilisation with a provisional prosthesis used as a guide
- Osteosynthesis of the osteotomy with a titanium plate
- Saline solution rinse
- Surgical wound closure with absorbable 4/0 and 5/0 suture

Osteotomy allowed to reposition the alveolar-implant entity.

Assessment criteria

Implant seating aims to achieve prosthetic rehabilitation. Insufficient bone volume, malpositioning, or incorrect implant angulation are frequent complications that may represent a short-, medium-, or long-term risk for that purpose. Consequently, our main criterion will be functional and aesthetic rehabilitation of the premaxilla sector in an already implanted bone volume, regardless of its initial angulation.

Thus, we will assess the clinical and radiological results in the maxilla based on the following criteria:

- Functional:

  Rehabilitation of pre-maxillary edentulism: prosthetically restored dental formula

  Occlusion:

    • Centring the mesial contact point

    • Absence of crossbite

  Implants/restored teeth ratio

- Aesthetic:

  The periodontium:

    • Presence of apparent post–traumatic tissue

    • Healthy periodontium

    • Height of the attached gingiva (>3 mm)

    • Gingival papilla filling the interproximal space: absence of inaesthetic “black triangle”

- Dental:

  Dental positioning and angulation

    • Repositioning following set-up and wax-up

  - Screw access hole in apparent facial position

Results:

We included three patients undergoing implant repositioning segmental osteotomy procedure at the oral and maxillo-facial department of Lille University Hospital for partial implant-prosthetic rehabilitation on atrophic maxillary and/or mandibular sector. Thirteen implants were seated and osseointegrated—85% in the maxilla and 15% in the mandible. Tooth loss was caused by bone atrophy in the anterior sector because of trauma (76%) and congenital causes (24%).

Clinical cases

Clinical case # 1

The patient had no medical or surgical history. He suffered face trauma in 2010 at the age of 14 with a triple mandibular fracture and a total luxation of teeth 11 and 21 (Fig. 2A). An attempt to reimplant the traumatised teeth led to post-operative failure two years later and the teeth were eventually avulsed.

An implant was considered to rehabilitate the maxillary anterior sector, but premaxillary atrophy prevented positioning and angulation of the implant in a prosthetically usable way. Besides, the patient presented class III skeletal ratios. Therefore, considering the necessity of orthognathic surgery to protrude the maxilla, it was suggested to place implants in the initial bone volume, then subsequently reposition them in a prosthetically usable way. Thus, the implants were seated in 2019, then repositioned after osseointegration (Fig. 2 and 3).

Clinical case # 2

The patient is a 20-year-old woman who presented with a cleft lip and palate; oronasal communication; agenesis of teeth 21, 14, and 18; and weak bone anchorage of teeth 11 and 12.

The patient benefited from orthodontic treatment and multiple surgeries to close the cleft.

In 2015, it was decided to perform maxillary osteotomy to avulse the remaining incisors, close the oronasal communication, and reconstruct the premaxilla.

After a six-month healing period, the site was somewhat vascularised owing to repeated surgeries and did not permit satisfactory reconstruction. The bone volume did not make it possible to place implants in a prosthetically satisfactory position and angulation (Fig. 4).

Thus, it was decided to place the implants in the pre-existing bone volume and surgically reposition them “ideally” after osseointegration.

Simulated bone mass displacement on a set-up before surgery with the provisional prostheses makes it possible to determine the segment position during the surgery.

Lastly, the gap resulting from the displacement was filled with an inserted autologous graft after cranial bone harvesting.

Clinical case # 3

Owing to trauma in February 2011, a 19-year-old patient presented with multiple fractures (bilateral parasymphyseal fracture, displaced right subcondylar fracture, and left condylar fracture) and multiple tooth losses in the maxillary anterior sector and mandibular right premolar sector.

After the first line fracture reduction treatments, the situation showed reduced bone volume associated with edentulism for teeth 13, 12, 11, 21, 24, 25, 44, and 45 (Fig. 5A).

To allow for implant rehabilitation, it was decided in October 2012 to perform sinus autologous grafts in sector 2 and apposition grafts in sectors 2 and 4. By then, the chin point was tilted to the left as a result of the ipsilateral condylar fracture.

In September 2013, sagittal osteotomy of the ascending ramus was performed for recentring purposes, together with placement of six implants (Fig. 5B) and lingually oriented segmental osteotomy of the mandibular incisal area to position it favourably in an occlusal orientation. After healing, the prosthetic analysis shows persisting anterior shift despite the appositional bone graft performed previously and despite mandibular teeth repositioning osteotomy (Fig. 5C).

Functional and aesthetic assessment

The results are given in Tables 1 and 2.

In the case of functional rehabilitation (Table 1), a number of teeth prosthetically consistent with rehabilitation of a complete formula is possible with a biomechanically favourable implant/number of teeth ratio (80%).

Afterwards, a transverse and anteroposterior analysis of static occlusion presented a centric positioning of the midline point and absence of crossbite in 100% of cases.

In the case of dental aesthetic rehabilitation (Table 2), the screw access hole is systematically non-apparent (100%) in the palatal position. This is justified by consistent position and angulation (facial/palatal) and made possible by subsequent surgery after set-up.

Last, none of the three clinical cases showed evidence of gingival periodontium: the periodontal architecture was rehabilitated with a prosthetic ceramic substitute.

Discussion:

In our technique the implants are inserted in the best position to be adapted to the available bone mass. In a second surgical step, It is the segmental osteotomy that puts the implant in the adequate position.

Therefore implant repositioning segmental osteotomy makes it possible to rehabilitate the premaxilla in an implanted bone volume, regardless of its initial angulation, allowing an anatomically and physiologically favourable occlusal function.

Contrary to the standard approach of pre-implant planning, it does not require any modification of the bone architecture prior to implantation: the planning will be done in the native bone volume, respecting inter-implant parallelism. This approach is less constraining because of its speed and the absence of cumbersome device (bone distraction) and will allow an implant-prosthetic rehabilitation by eliminating the healing period (4–5 months) and the secondary risks of resorption of the onlay graft. In addition, an esthetic process immediately following the segmental osteotomy will be possible.

The anteriorly osseointegrated implants will simply be moved, but will already be able to allow esthetic rehabilitation subject to a maxillo-mandibular blockage until bone consolidation.(11)

Finally, this practice will limit the risk of implantation error both on angulation and positioning, because the displacement of the volume will be guided by the prosthetic project in accordance with the functional and aesthetic objectives. The only limit for the movements will be the remaining periosteum providing the vascularisation.

Thus, a wide range of surgical techniques and autogenous, allogenous, xenogenous, and synthetic biological (12) materials (Table 3) are available, making it possible to reconstruct the premaxilla, but with little predictable (13) complication risks.

To take the most strategic therapeutic decision, some authors (14) have determined the criteria to be measured: reduction of morbidity and the number of procedures, financial considerations, predictability of healing, and healing time.

In that context, several studies have reviewed the various current techniques and compared their results in terms of implant-prosthetic rehabilitation:

1 - Distraction osteogenesis provides superior amount of vertical bone gain with shorter healing time (3 months ≠ 6 months) (15) in the case of minimal residual width of 3 mm. After healing, the implant survival rates are 95% (16) , similar to native bone. Nevertheless, distraction osteogenesis also causes considerable inflammation with large amounts of fibro-mucosa and short- or medium-term severe bone resorption that may require a pre-implant alternative (17) .

Thus, if the technique seems intellectually appealing due to gain in attached fibro-mucosa, the results seem very fluctuating in the context of the premaxilla, with major aesthetic demands. In addition, even if the distraction devices have a reduced volume and remain intra-tissular, they need at least a transgingival fixation or activation with functional impairment for the patient.

2 - Guided bone regeneration (GBR) (absorbable membrane/autogenous bone) involves biocompatible tissue integration associated with the creation of a dimensionally stable area for growth, and this technique is frequently suggested for bone reconstruction. This principle “protects” the grafted area with the placement of a membrane. Reconstruction is often performed with bone or particle biomaterials. This technique needs perfect vascularisation, low volume reconstruction and/or unidimensional reconstruction and a long healing period if biomaterials are used.

One of the disadvantages of a particle graft is the lack of graft stability. Indeed, at least minimum stability is required for satisfactory graft set. Mobility quickly causes fibrosis and

then resorption. The other drawback of that technique is the infectious risk due to the presence of the membrane and biomaterials, even after a long healing period if biomaterial is not totally replaced by vascularized bone. Therefore, titanium meshes have been suggested as an alternative to membranes, thus making it possible to keep grafts in place whatever their origin.

According to a retrospective study published in 2008 (17) , GBR (with autogenous bone and titanium mesh) could yield an average vertical increase of 13.7 mm with a favourable success rate (97%) for up to 7 months' healing time.

However, the limits of GBR are related to graft vascularisation. Vascularisation time is the first cause of infections occurring on those reconstructions.

Further, the higher the bone mass to be grafted, the higher the risk of failure (7) . With titanium meshes, vascularisation is also reduced but in a lesser way. Besides, membranes and titanium meshes interfere with bone remodelling. Furthermore, standard membranes may be exposed, which may be uncomfortable, even if those situations are currently managed satisfactorily. Last, in some cases, titanium meshes may have to be removed for satisfactory implant placement. None of those disadvantages could be observed with our technique.

3 - Ridge expansion described by H. Tatum in 1986 (18) is also a technique that allows to gain bone volume is the premaxilla area (19) . It is based on bone tissue plastic properties, and gradually provides sufficient inter-cortical sagittal space for implant placement with 98% success rates (20) .

According to published literature, this technique yields a gain of 4–5.5-mm in width and possibly up to 40 mm in length.

However, minimal ridge thickness for this type of expansion must be 1.5–3 mm. In case of insufficient thickness, an alternative technique will have to be considered.

Last, bone expansion is a good technique, but only for anteroposterior deficiencies that would require an average gain of 4–5 mm (21) . Thus, important deficiencies cannot be treated with this technique when two dimensions require reconstruction.

4 - Onlay bone grafting is a reliable technique favoured by the biological concept of cortical bone use to obtain a stable membrane coffering. The vascular supply from the grafted site is often complex in the extremities of the graft. That vascular difficulty induces a graft resorption risk. There is no such risk with our technique. Besides, according to Ferri et al. (7) , in case of major premaxilla atrophy, it is not recommended to perform a single graft, considering the resorption risk. In those cases, it is recommended to perform a Le Fort I which has many advantages: (22)

- It solves both bone deficiency and the gap in jaws in a single surgical procedure
- It improves inter-arch relationships, thus simplifying the prosthetic rehabilitation to come
- The grafts are positioned in reasonably ideal sites
- It improves the facial appearance by making it harmonious

Implant repositioning also uses the concept of displacing the occlusal bone supports. Thus, with our technique, inter-arch relationships are back to normal at the premaxilla level, and the positioning is optimal in the implant prosthetic axis despite incompatible initial bone volume.

However, post–traumatic tissues, marking the limits of the displaced area, were unfortunately observed in all three of our patients. Those scars may be impaired depending on the high smile line and the prosthetic transition line.

Therefore, it is difficult to only relate those post–traumatic tissues to segmental surgery. It is very likely that the trauma caused important dental alveolar loss and is the main reason for the presence of post–traumatic tissues. Indeed, in the standard type of orthognathic

surgery that is close to the technique described here, that complication is well-known but rarely reported.

An alternative to implant repositioning segmental osteotomy is pre-implant segmental osteotomy. However, two limiting factors that are inherent to that technique should be mentioned:

- Bone resorption: indeed, alveolar bone has a quick turn-over and retaining its level is mainly dependent on the occlusal loading. This is essential to make it durable. This constraint is usually borne by the dental organ. It can also be borne by an implant. In that context, a secondary implant is a non-negligible resorption risk due to the time interval between osteotomy and implant placement, and to the surgical act being performed in an area at high resorption risk after displacement. Therefore, that technique does not seem to be suitable for that type of rehabilitation given the = osteotomy strengthening interval and bone resorbing pace.
- Bone segment guidance: It is worth reiterating that occlusion is the main implant stability factor. Therefore, it acts like a repositioning guide for the severed alveolar-implant segment. Severing the alveolar structure without implant guidance poses a threat as to correct positioning of the severed alveolar bone. We faced no such challenge with our technique.

One of the main challenges with our technique is surgical planning. Indeed, whatever the laboratory simulation on model studies, positioning the alveolar-implant fragment remains unpredictable. Those difficulties can be accounted for by limited maxillary palatal fibro-mucosa malleability, but also because sometimes the surgeon’s experience is not enough to determine the right positioning that cannot be corrected only by checking dental occlusion.

Consequently, it is quite clear that information technology (IT) planning would undoubtedly prove useful, as it would combine implant placement and subsequent segment displacement (Fig. 6A, 6B).

Several IT tools are already available and used for virtual set-up in implant surgery. Combining a digital imaging and communication in medicine (DICOM) file from a radiological tomography process with a stereo-lithography (STL) file from the optical impression of the patient's arches would make pre-surgery planning easier. It may even help in the preparation of advance occlusal splints, as described by previous authors, as guides helping for adequate positioning of the bone segment and then favouring strengthening. (23,24)

Finally, implant dentistry with severe mucogingival deficiencies remains an important challenge to this day, and it is often not overcome in dental alveolar losses adjacent to the premaxilla. This situation was observed in case #1. With biomimetic rehabilitation as the intended goal, it is a legitimate question, particularly in the premaxilla sector.

Indeed, aesthetic management encompasses the dental, periodontal, and mucous aspects according to the criteria of the White Aesthetic Score and the Pink Aesthetic Score (25) .

A key element is the presence of an interproximal papilla, whose management is directly related to bone periodontal support. The principle of a 3-mm distance to be kept between two adjacent implant elements is derived from the principle of preservation of the biological space in the mesio-distal plane (26) .

Plastic surgery can then be useful in the pre-implant or post-implant phases with comparable results up to one year after implant placement. However, it seems that pre-implant treatment is best adapted for severe deficiencies in keratinised tissues (27) .

Although several techniques, supplying tissue or not, have been described, none of them seem to reach a consensus in terms of peri-implant (27) mucosa increase. The only

technique that stands out is connective autogenous grafting, which proved to be superior to xenogenous collagen matrix (28,29) .

Considering the major aesthetic disadvantages of an epithelial connective graft, it is difficult to use that technique alone in the premaxilla sector, except in the case of a low smile line. Supplying a peri-implant connective graft is more satisfactory for patients (30) as it provides more thickness than a free graft (31) .

The so-called ‘combined grafting’ technique is based on the combination of an apically positioned flap, an epithelial connective graft, and a xenogenous collagen membrane. It seems promising, with an average significantly stable gain of 6.33 mm of keratinised tissue at 12 months (27) .

Nonetheless, those actual difficult aspects of gingival alveolar aesthetics should not only be related to the technique suggested here. They are quite common to all premaxilla reconstruction techniques and to this day, have not been solved by the alternative techniques described herein. Additionally, mucogingival surgery can be performed subsequently once the occlusion and implants are in place.

Conclusion:

Alveolar implant osteotomy seems to be a reliable technique that allows for stable, durable occlusion from implant structures. We acknowledge that three patients are not enough for our results to be conclusive, and a larger group of patients would be required to validate this data set.

However, we believe that the discussed technique solves several difficulties for which at this stage, there is no other therapeutic option.

The authors declare that they do not have conflicts of interest associated with this publication

Tables and Figures:

Table 1:

Table 1 - Functions				
	Clinical case #1	**Clinical case #2**	**Clinical case #3**	**Results**
Prosthetically restored dental formula	YES	YES	YES	**100%**
Implants/restored teeth ratio	4/4	3/4	4/6	**80%**
Centring the mesial contact point	YES	YES	YES	**YES**
Absence of crossbite	YES	YES	YES	**YES**

Table 2:

Table 2 - Aesthetics					
Periodontium and mucosa	**Presence of visible vincula**	YES	YES	YES	**100%**
	Height of attached gingiva	NO CERAMIC GINGIVAL SUBSTITUTE IN THE SURGICAL AREA			**0%**
	Healthy periodontium (Löe and Silness)				
	Gingival papilla filling the inter-proximal space: absence of inaesthetic "black triangle"				
Dental aesthetics	**Positioning and consistent angulation**	YES	YES	YES	**100%**
	Apparent facial prepared area positioning	NO	NO	NO	**0%**

Table 3:

Extra-oral sample	**Bone resorption with skull sample**	Smolka (2006) after 6 months: 16%
		Iizuka (2004) after 1 year: resorption<1 mm
	Bone resorption with iliac graft sample	Sbordone (2009) after 1 year: resorption up to 59%
		Carinci (2005) after 10 months: resorption 39%
Intra-oral sample	**Bone resorption with mandibular symphysis sample**	J.F. Tulasne (2014) after 6–24 months assessed to be ≤15% (average follow-up at 16 months) → According to the study, the bone volume gets stable 1 year after the operation without continuing resorption
		Sindet–Pedersen and Enemark report graft resorption ≤25% after 8 months' post-operative follow-up

Figure 1:

Figure 2: (A, B, C)

Figure 3: (A, B, C)

Figure 4:

Figure 5: (A, B, C)

Figure 6: (A, B)

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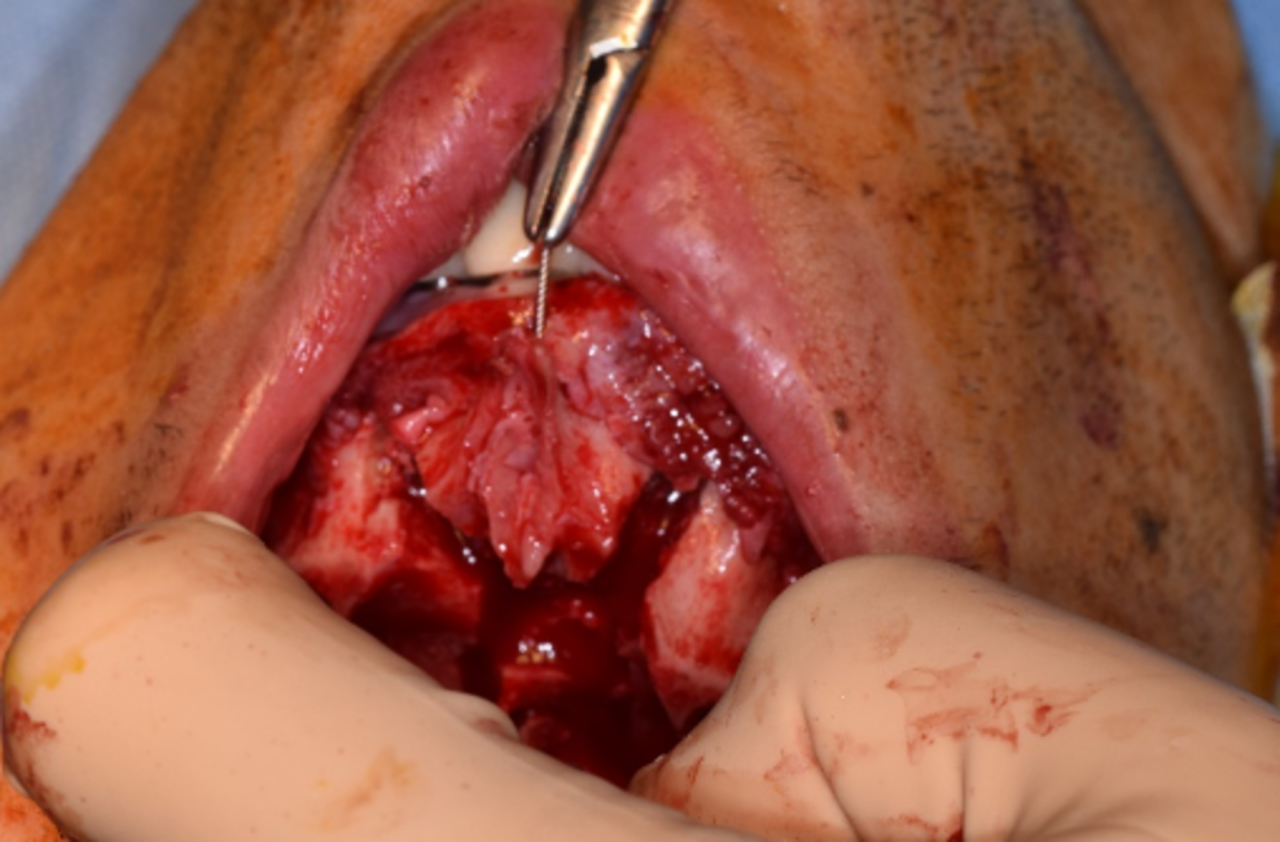


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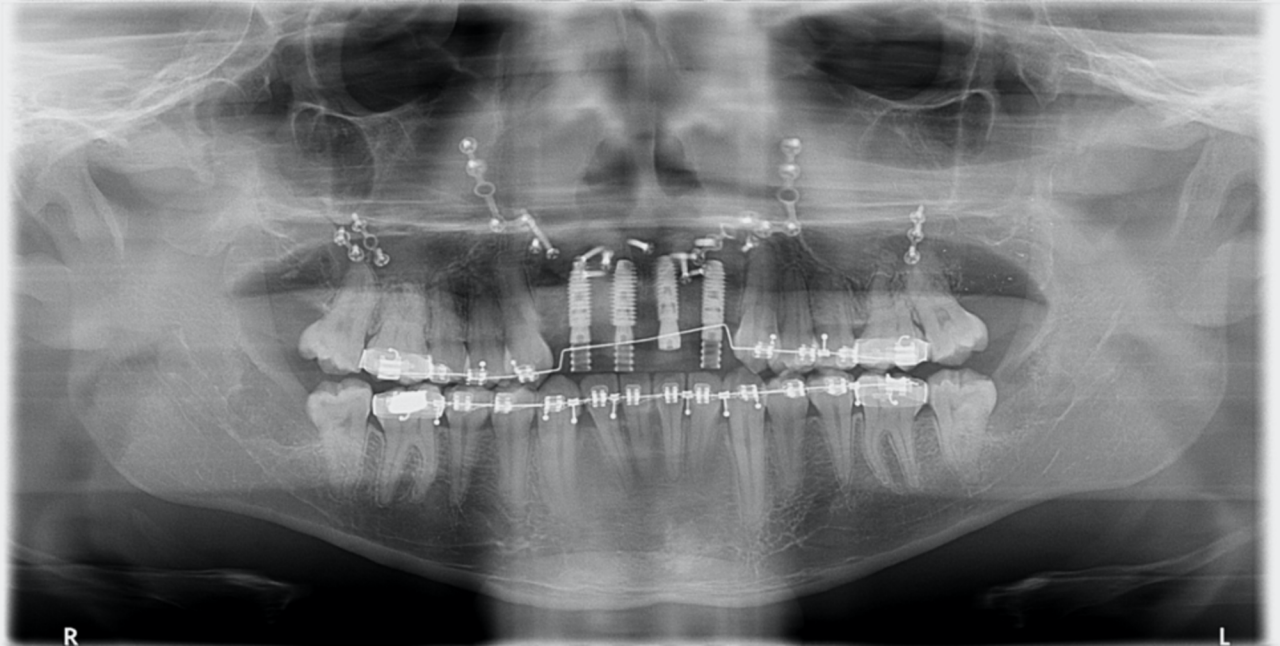
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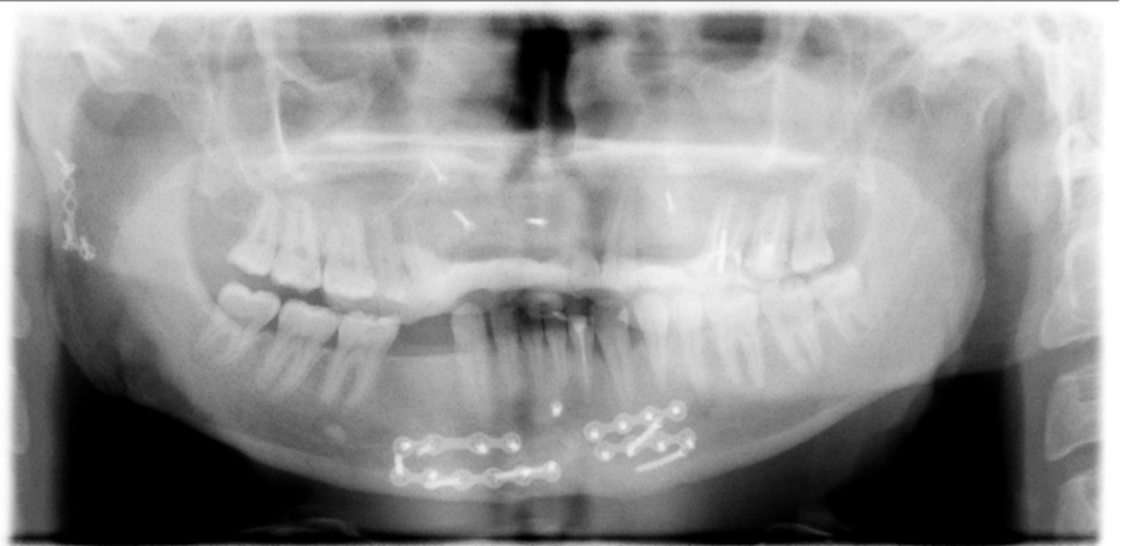
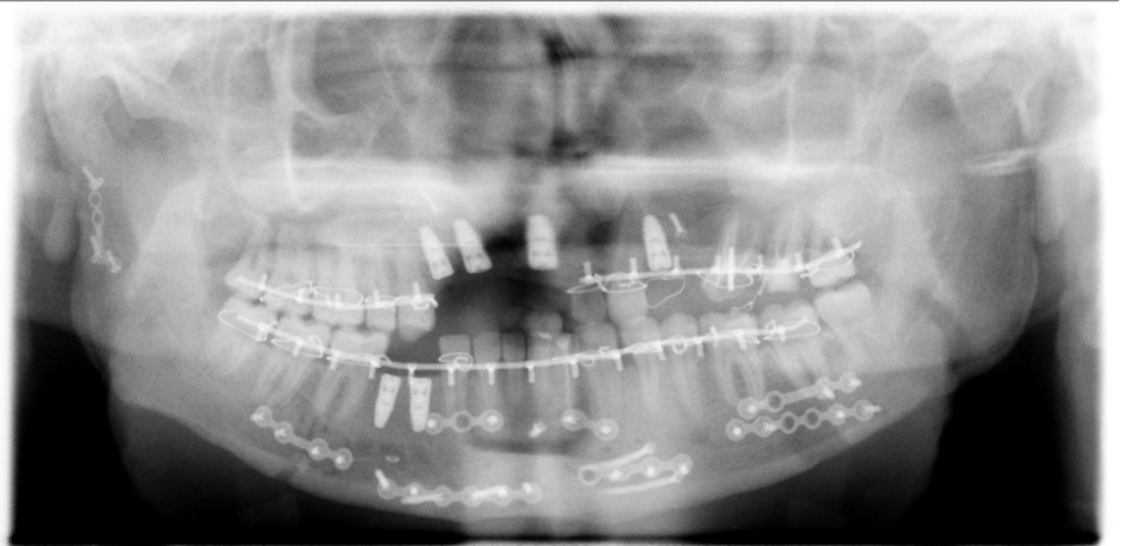
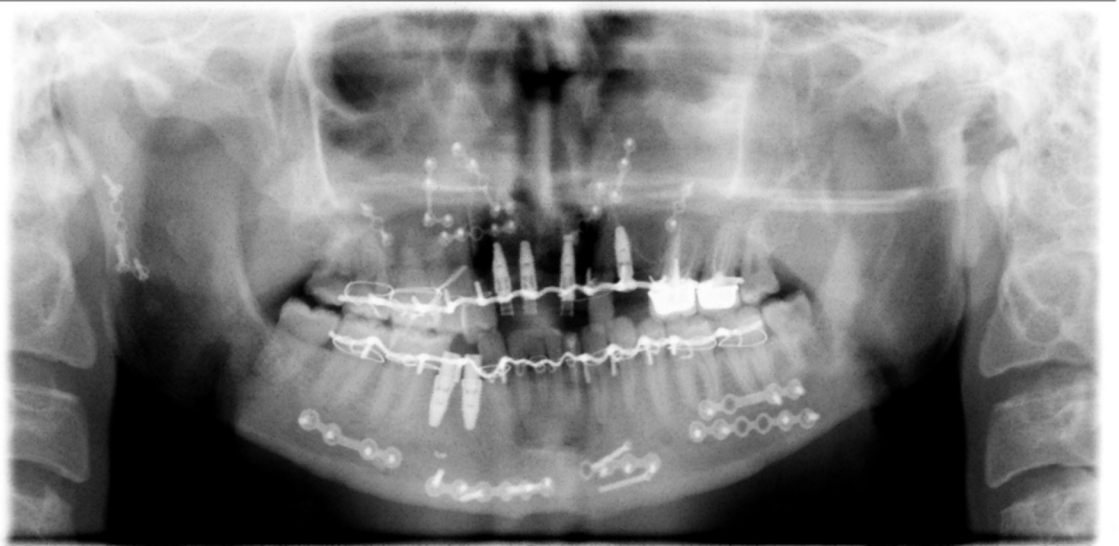
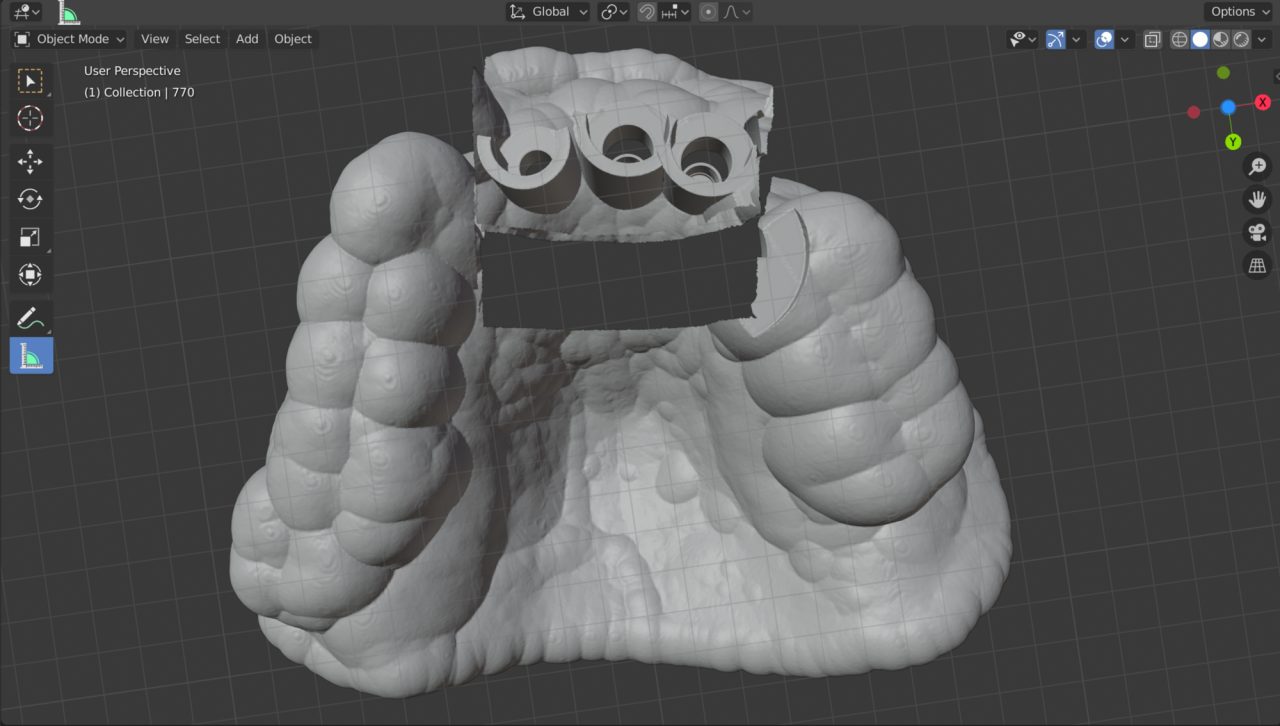







Object Mode
View
Select
Add
Object
User Perspective
(1) Collection
X
Y


Global
Options
Object Mode
View
Select
Add
Object
User Perspective
(1) Collection | 770
X
Y