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he evolution of knowledge in the field of odontology in the last few years has brought about a real revolution in our dental offices. The expertise of dentists has been improving as our patients have become increasingly demanding.



Dr. Bertrand Baumann

Today, our knowledge of biomaterials, mastery of osseointegration processes and understanding of bio-mechanical models have provided us with a slew of technical options to restore our patients' health. Are there no limits to what we can do?

We all know that actual clinical practice is quite another story. Today's compromises will be tomorrow's failures. Implant surgery and implants in the anterior region are no exception.

Bleu Blanc Dent, in partnership with the industry takes part in research and innovation in the field of odontology. Our team's expertise is but the result of the pooling of our knowledge and a critical analysis of our failures.

The aim of this paper is to take a step back and think about the importance of implant axes and their consequences on dental prostheses. Implantology is not an end in itself, it is merely at the service of the dental prosthesis.

Dr Bertrand BAUMANN and his team wish you all the best.

Enjoy the read !

Dr Bertrand BAUMANN
and the Bleu Blanc Dent team

Journal written in collaboration with
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Clinical work carried out by Dr Bertrand BAUMANN

Exercise in implantology and pre-implant surgery, Soultz (Haut-Rhin), France
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There is no denying that therapeutic solutions are made possible today thanks to implantology. Thousands of papers available in the scientific literature reflect the growing interest in this field over the last ten years.

Favorable statistics, very encouraging results and the very low failure rate in implantology described in the literature could lead us to believe that the process is easy, and even imagine that we have a lot of leeway in our practice.

Unfortunately, the clinical reality is very different. The demanding nature of the job is sometimes demeaned and social networks contribute to debates that have little to do with science. Implant surgery must maintain its status like all medical specialties.

The prosthetic rehabilitation of our patients is the only purpose of our treatments. In the case of fixed dental prostheses, the dental surgeon must lay out his or her treatment project taking into account the anatomy of the supporting teeth. In implantology, we are in uncharted territory. The practitioner is free to approach

each new rehabilitation as a new creation he or she will have to design with one goal in mind: replace the missing teeth.

The kinematics of dental arches during chewing as well as the repartition of forces on the teeth are well known.

Whether it is a tooth prosthesis which does not work on the same axis as the implant, or an implant which is placed outside the bone volumes or reduced implant dimensions for anatomical reasons in an occlusal context of bruxism, these will all lead to bad results. When replacing a missing tooth by implant prostheses one should bear in mind such rules or our intervention will fail. The positioning of the implant must take into account all the environmental constraints to our rehabilitation. Preserving the peri-implant keratinized gingiva, the respect of bone volume at the implant site, the proximity of teeth and the root axes near the gap, the orientation and morphology of opposing teeth as well as the harmony of occlusal curves are all parameters that are to be taken into account to optimize the implant axis without compromising the prosthetic axis ⁴.

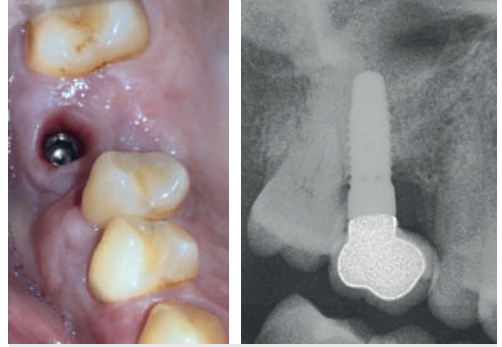
LEARNING FROM OUR FAILURES

CLINICAL SITUATION N°1

The positioning of a single implant is the simplest clinical situation in implantology. Yet it implies by no means that this act is simple to carry out.

Ideally, the implant should be centered on the ridge, in the mesio-distal direction as well as in the buccal-palatal direction in the maxilla or buccal-lingual in the mandible.

If these few rules are not respected the periodontium will suffer, hygiene around the implant will be difficult and the upper part of the prosthesis will not work in the axis of the implant.

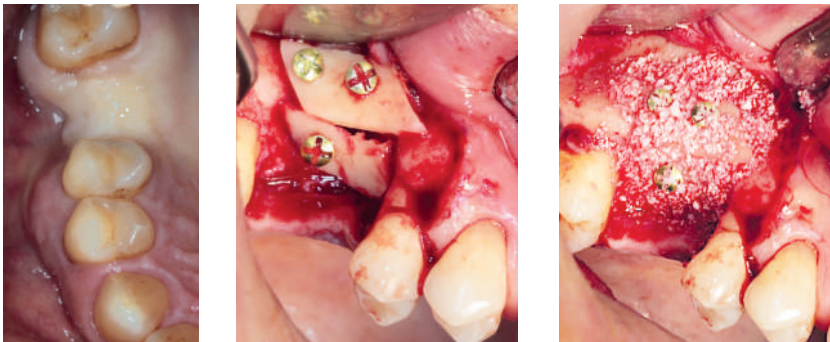


Clinical situation and X-ray centered on implant 16

As a result, the site will suffer, the patient will be inconvenienced and the implant may be lost. This unfavorable outcome will arise if the position is either too distal or vestibular in position 16. The clinical result is a periodontal pocket 12 mm away in the vestibular area with purulent discharge and pain.

For this patient, we realized an explantation and onlay bone grafting from autogeneous bone

after 3 months of healing. A new implant will be repositioned once the bone is healed 6 months after the operation. The aim of this bone reconstruction is to recreate favorable bone and gum volumes to allow for optimal implant positioning. If the implant is well-centered in the gap and the prosthesis works in the axis, the implant therapy will be successful.



Autogenous bone graft with retro-molar harvesting + Bio Oss

CLINICAL SITUATION N°2

Replacing several missing teeth is even more of a clinical challenge in implantology. The practitioner is faced with reduced and degraded spatial references. Morphologically, a largely toothless site suffers from bone and mucosa remodeling that is usually more important than in the case of a single tooth gap. The order in which teeth are lost may differ with direct impacts on the migration of opposing teeth and thus on occlusal planes.

As with partial dentures, the teeth must be positioned in the patient's prosthetic lane. This virtual space must take into account the toothless ridge but also muscle and ligament insertions around the site. We will describe later in this paper how the use of surgical guides allows us to position the implants in the future prosthetic volume.



Clinical situation and X-ray of sectors 22-23-24, 18 months after treatment



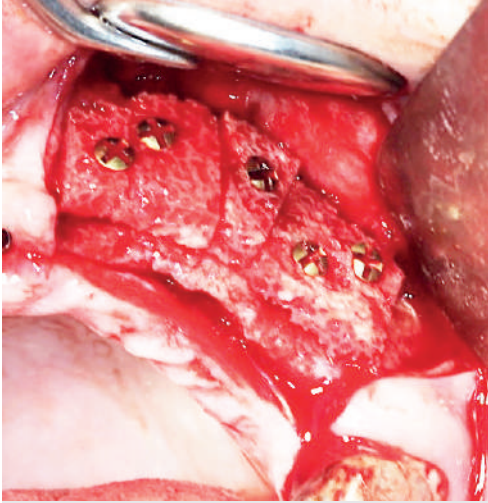
Clinical situation of implant axes in 22 and 24

This 71 year-old patient came to us for a consultation after the rehabilitation, 18 months before, of sectors 22-23-24. Mrs L. was not happy with the result which did not meet her expectations aesthetically.

Hygiene was impossible around the site; the lack of nearby spaces along with the presence of resin on the prosthetic tooth necks were iatrogen co-factors which were part of the process of the buildup of a periodonto-pathogenic biofilm. The gum was painful because of a lack of keratinized tissues. The prosthetic volumes invaded the vestibule and pushed back the mucosa and muscle insertions. The upper lip was overly supported with functional discomfort and difficulty to comfortably reposition the labial tissues.

The removal of the existing bridgework and the positioning of 2 impression copings enabled us to visualize the unfavorable implant axes with an emergence outside the dental arch perimeter.

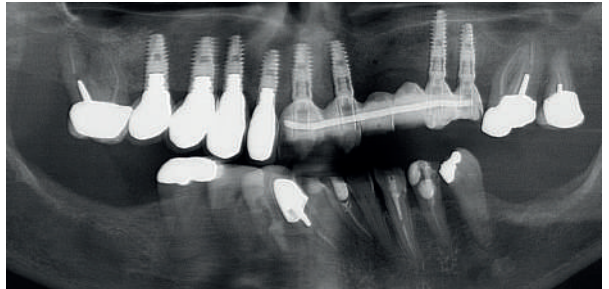
IMPLANT AXIS AND DENTAL PROSTHETIC AXIS



Allogenic bone graft

In this context, it was impossible to keep the two implants. We extracted teeth 11 and 21 which were mobile, then explanted the implants in 22 and 24 and made an allogenic bone graft associated with a sinus lift by lateral approach.

After 6 months, we positioned 4 new implants (with geometric parameters identical to the previous ones) respecting the prosthetic lane. We immediately loaded sector 11 to 25 with a temporary screw-retained prosthesis with palatal implant emergencies. Sector 22-23 was spared on purpose because the quality of the reshaped mucosal tissues was insufficient to be fitted with a temporary prosthesis. A 15N tightening torque was applied during the fitting of the temporary prosthesis after 48 hours



Implant positioning in prosthetic lane



Clinical situation one month after immediate loading

– THE THOUGHT PROCESS BEFORE PROSTHESIS IMPLANTATION –

The supra-implant prosthesis is key to successful implants. For clinicians it is unforgiving. A forewarning will come at once in case of a digression and sure failure will ensue. It is necessary to start the thinking process leading up to the surgical gesture which will merely be the clinical expression of the adopted prosthetic solution.¹⁻³

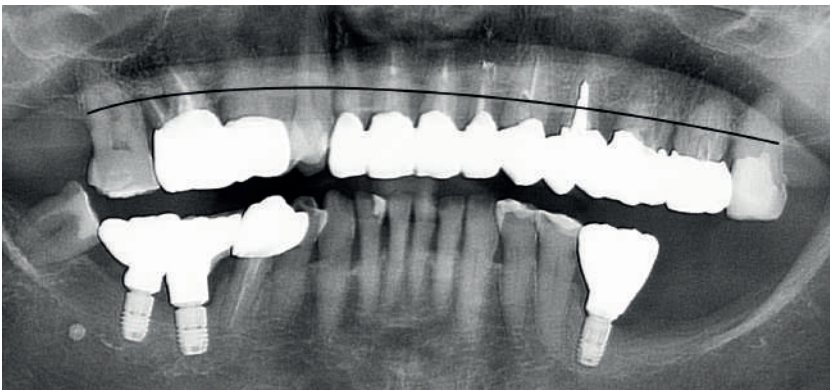
The choice of the implant axis is at the heart of our work and this choice alone has a bearing on the future environment of our prostheses.

CLINICAL SITUATION N°1

This 66 year-old patient, with no previous medical condition, was referred to us by her treating dental surgeon for a rehabilitation on sector 12 to 26.



Initial clinical situation



Initial X-ray situation

IMPLANT AXIS AND DENTAL PROSTHETIC AXIS

The patient suffered from a chronic periodontal disease with a horizontal bone lysis, as a result the clinical crown to root ratio was unfavorable for all the supporting teeth of the bridgework from 12 to 26 (see markings on X-ray).

When we examined her we found pockets of more than 5 mm on all the teeth in the same sector, mobility as well as subgingival cavities under the prosthetic restorations. The treating practitioner cemented the prosthetic restorations on several occasions and explained to her how serious the situation was. In such conditions there was no way we could keep the abutments and we opted for avulsion.

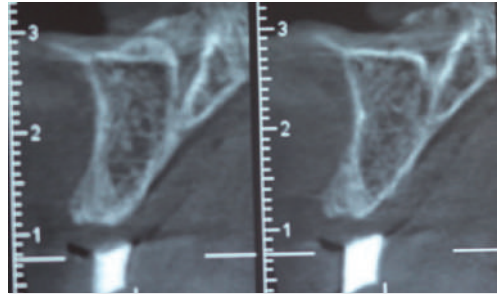


Painful implants on 46-47

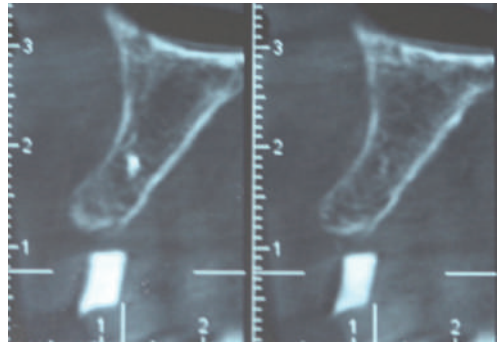
The mandibular implants fitted 24 months earlier by a colleague were not satisfactory, besides the patient complained of pain and chronic gingival inflammations in sector 46-47.

First we decided to preserve the mandibular arcade to allow a rehabilitation on the maxillary arch in a more favorable occlusal situation.

In order to optimize the positioning of our 7 maxillary implants we made a master plan that we validated in the mouth. X-ray guidance based on this master plan was used so as to correlate the bone volumes and the axis of the alveolar ridge with the position of the future teeth with regard to each implant. It can be noted that on the scanner slices the alveolar bone volumes are favorable while the prosthetic axes differ from the axes of the ridges.



*Scanner slices
with X-ray guidance*



*Scanning sections
with radiographic guide*

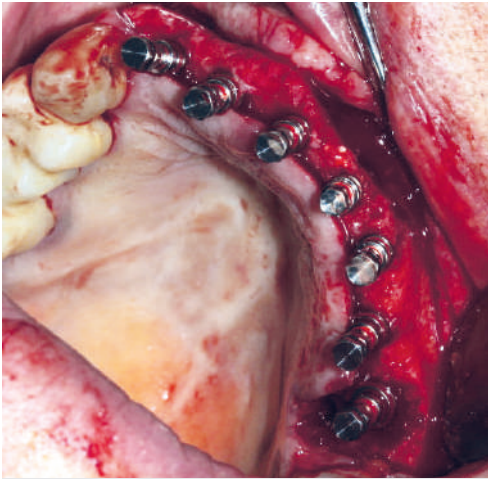
Our surgical work consisted in finding the best compromise between the patient's anatomical constraints and the demands of the prosthesis. Technically, we tried to straighten the implant axis at best while maintaining the integrity of the alveolar bone volumes.

IMPLANT AXIS AND DENTAL PROSTHETIC AXIS

After fitting the 7 Thommen maxillary implants, we realized a guided bone regeneration with Bio Oss + an absorbable membrane on the whole buccal vestibular side

When he made the temporary bridgework, the prosthesis performed a direct implant screw-retained prosthesis.

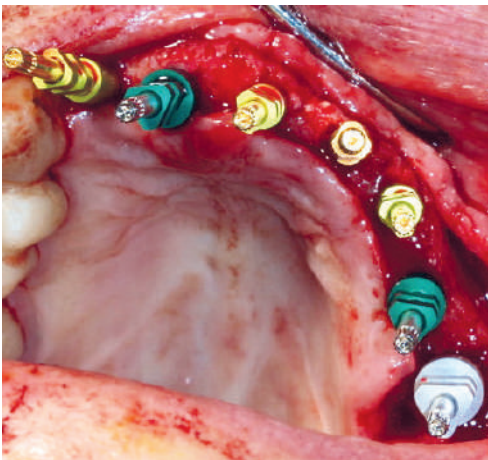
The compliance with specifications defined before the surgical gesture made laboratory work easier. On sites 12 and 22 it was not possible to obtain a palatal emergence of the screw channel without compromising the integrity of the ridge. A 15N torque was applied for the fitting of the temporary prosthesis 48 hours later.



Fitting the 7 single tooth Thommen implants



Realization of a temporary bridge by lab

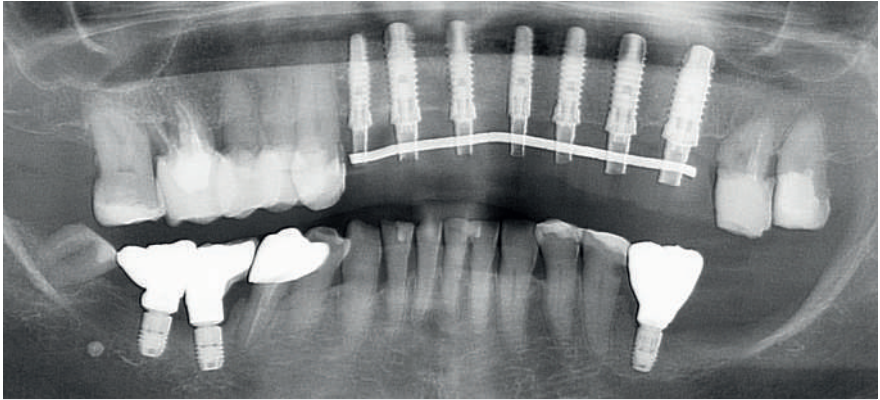


Impression with open tray impression on the 7 Thommen implants



Realization of a temporary bridge by lab

IMPLANT AXIS AND DENTAL PROSTHETIC AXIS



Post-op X-ray during loading 48 hours later



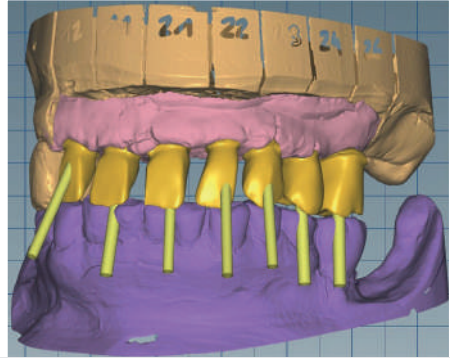
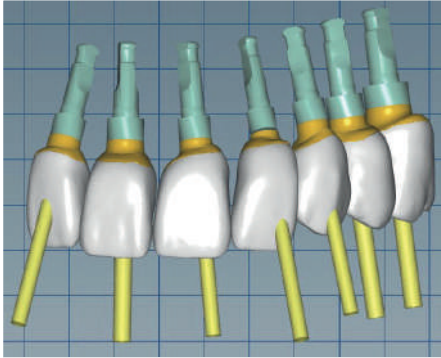
Post-op X-ray during loading 48 hours later

6 months later, the final rehabilitation was realized by the treating dental surgeon in collaboration with the HAAS laboratory.

Since the prosthetic rehabilitation of our patient concerned the whole maxillary arch it was essential to look at this reconstruction from a global perspective. The work on the coronal and occlusal morphology of

maxillary teeth would have to be realized in harmony with the mandibular arch. In order to recreate more favorable occlusal curves, coronoplasty by addition or subtraction was realized on the mandibular teeth.

IMPLANT AXIS AND DENTAL PROSTHETIC AXIS



Modeling of anatomical abutments by HAAS laboratory

Numerical modeling thanks to the ALL Shape system allowed to compare the implant axes and the prosthetic axes. Close collaboration between the dental surgeon and the prosthesis is essential at this phase. Comparing clinical demands and the constraints of CAD/CAM allowed to conceive ideal supra-implant structures. During the modeling process we were able to correct the divergences of implant-prosthesis axes. It was of the utmost importance to take into account recent scientific knowledge

in order not to compromise the biomechanics of our restorations and end in clinical failure.

In this case, 7 titanium custom abutments machined by All Shape and 7 full ceramic crowns (zirconia coping) were made. Teeth from 12 to 23 were cemented to respect implant axes and avoid screw channels on the incisal or buccal surface; teeth 24 and 24 were screw-retained with occlusal emergence.



Final clinical situation after a year

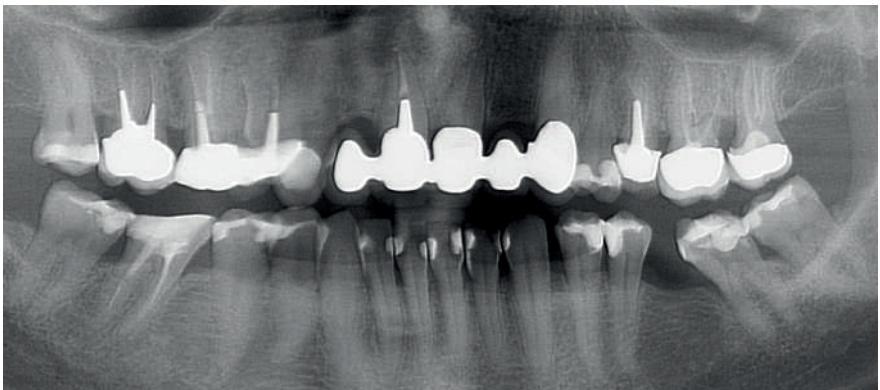
CLINICAL SITUATION N°2

This 50 year-old patient was referred by her treating dental surgeon for extraction of teeth 12-11-21-22-23.

The fixed anterior plural prosthesis regularly came loose in a context of recurring cavities on the supporting abutments. When we probed at 10 mm, tooth 11 had a cracked root on palatal side, tooth 23 had a deep palatal cavity more than 3 mm beneath the bone ridge. It was decided not to keep tooth 21 with a mesial cavity which might have compromised the final aesthetic result



Initial clinical situation

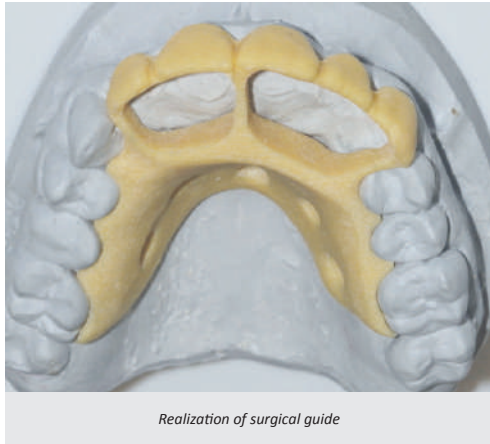


Initial panoramic X-ray

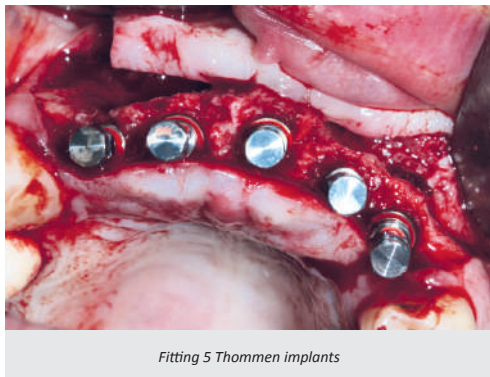
IMPLANT AXIS AND DENTAL PROSTHETIC AXIS

Teeth 11-21 and 23 were extracted and a removable temporary resin prosthesis was made by the lab.

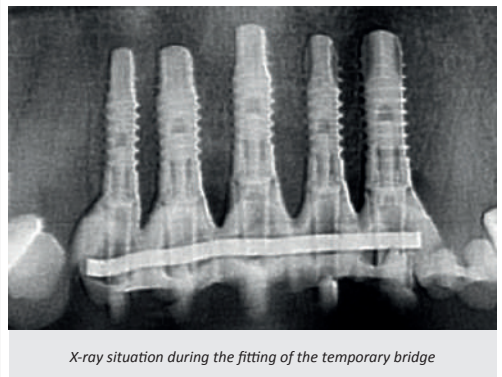
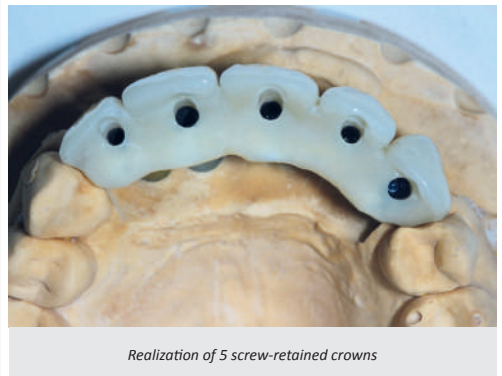
After 3 months of healing, we validated the prosthesis master plan in the mouth in order to realize a surgical guide which was to help us for the positioning of the 5 Thommen implants²⁻⁵.



A guided bone regeneration was realized with Bio oss + absorbable membrane on the buccal side. For the temporary aesthetic prosthesis, direct implant bridgework of 5 joined teeth was realized.



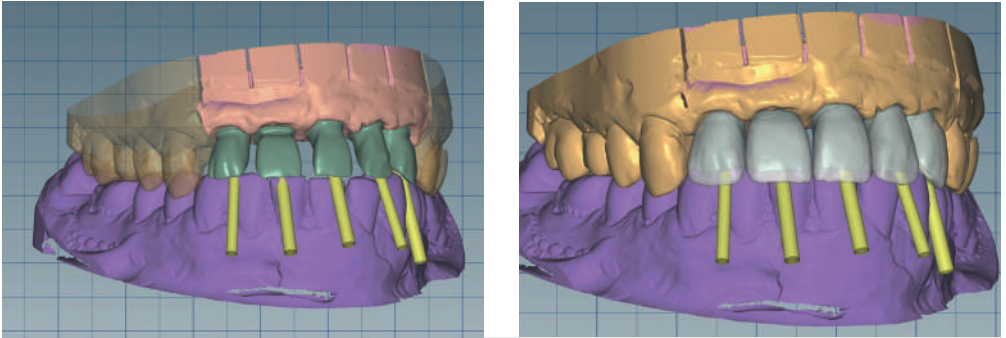
In the case of this patient, it was possible to correlate the implant axis with the prosthetic axis while respecting the integrity of the bone volume. The screw channels were positioned in the palatal area for each implant. A 15N torque was applied for the fitting 48 hours later.



IMPLANT AXIS AND DENTAL PROSTHETIC AXIS

The final rehabilitation was realized by the treating dental surgeon in collaboration with the HAAS laboratory.

In this second clinical situation, numerical modeling allowed to validate the coherence of implant axes and prosthetic axes. For a better aesthetic result we chose to make 5 full ceramic crowns with titanium abutments machined by All Shape.



Modeling of anatomical pillars by the HAAS laboratory



Final clinical situation after a year

Conclusion

Even if implant surgery remains a demanding discipline, it is not an end in itself. The implant is just the support to fix a prosthesis.

The choice of our implant axes must, clinically speaking, take into account :

- The periodontal environment of the site
- The residual bone volumes of the edentulous sector
- The neighboring teeth and opposing teeth

But, in order to be thorough one needs to keep in mind :

- The prosthetic choice for the final restoration
- The axis and constraints transmitted by the prosthetic supra structure

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While fitting an implant is a surgical act, the three-dimensional positioning derives from a pre-surgical analysis based on prosthetic, biological and anatomical criteria. The finer pre-implant analysis can be envisioned only once we can discard possible contraindications of a general nature, and the patient's mouth has been prepared, namely in the periodontal aspect. This analysis must be submitted to precise and computer based planning which will determine the positioning of the implant in the 3 spatial dimensions : buccal-palatal, mesio-distal and vertical.

THREE-DIMENSIONAL POSITIONING OF IMPLANTS

Proper implant positioning must respect several factors :

- **The planned prosthesis** : the position of an implant is simply the planning of a prosthesis which it is essential to define and validate with the patient from the outset. This planning must establish very accurately the desired orientation of the teeth, their width, the position of the clinical collar.
- **The biological space¹** : now called bi-tissular supra-crestal complex. This is a three-dimensional healing space between the bone level and the bottom of the sulcus. The tissues, conjunctive and epithelial that make up that space provide the hermeticity of the mucosal attachment around the implant. This is a very fragile space in implantology. The attachment to the structure underneath is weak because there is no cement on the surface of the implant, and the orientation of the fibers

is parallel to the surface of the implant. This biological space is made up of 1 mm of connective tissue and 2 mm of junctional epithelium, so a total of at least 3 mm, to which the depth of the sulcus needs to be added.

- **Connection types** : there are two types of implants, with or without a smooth neck, and two types of connections, internal and external. The smooth neck, according to its height, is meant to support all the biological space or part of it. Its insertion in the bone tissue causes resorption of the marginal bone² up to the junction between the micro-textured titanium and the smooth neck. In some cases, often associated with an internal Morse taper connection, the abutment is of a diameter which is inferior to that of the implant. This platform switching brings about

a particular formation of the biological space on the implant supra-structure and requires a more apical positioning of the implant by about a millimeter.

- **The mode of prosthetic assembly:** numerous studies³ have shown both how difficult it is to eliminate the excess of sealing cement, and the causal link between excess cement and occurrences of mucositis and periimplantitis.

These results must lead the practitioner to adopt an implant position that will give the surgeon the choice between a screw-retained prosthesis or a cemented prosthesis. When a cemented solution is preferred, it is highly recommended to opt for custom titanium, or hybrid titanium/zirconia abutments. This will then allow to position the limits of the abutment and thus the sealing at a supra-mucosal level or at most intrasulcular level and to partly guarantee the removal of excess sealing material.

- **Peri-implant vascular deficit :** the peri-implant tissues are less vascularized than periodontal tissues for various reasons, the most important of which are the loss of desmodontal vascular supply, as well as the vascular shunt caused by osteotomy and the implant itself. This lower vascularization dictates positioning which leaves more room to peri-implant tissues. The peri-implant bone must be thick enough to contain its own vascularization⁴. It is essential to keep this in mind in the areas where the natural teeth roots are close together, as in the anterior mandibular area, in which case an implant solution will be impossible.

- Taking into account anatomical obstacles (adjacent nervous, vascular, dental or cavity anatomical structures) and respecting safety distances of at least 2 mm.

- The patient must be able to have proper hygiene practices. Too much disharmony between the implant position and the surface of the prosthesis causes overhangs which are areas of bacterial plaque retention, often leading to infectious complications.

The perfect positioning of the implant is one of the main factors of biological, functional and aesthetic integration and of stability of the end result.

Once the planned prosthesis has been validated, the pre-implant analysis always follows the same methodology, using computer based technology. This method allows to accurately define the three-dimensional position of the implant in the pre-surgery phase, but also to replicate this positioning precisely in the surgical phase by the use of guiding systems, either static or dynamic. The various steps are :

- Digitization of the planned prosthesis.
- Acquisition of three-dimensional imaging.
- Superimposition of STL file of imaging and the DICOM file of the imaging.

- Planning the implant positioning in compliance with all the aforementioned factors.

Even if an implant axis far from the prosthetic axis does not lead to, according to the literature, a significant increase of biological or mechanical⁵ complications, only a very small group of different implant positions can reconcile all the factors conducive to functional and aesthetic success in the medium and long term.

Rules of three-dimensional positioning of implants ;

- **Mesio-distal direction :** the aim is to ensure sufficient mesial and distal bone thickness to supply vascularization of the bone tissue. At least 1.5 mm between a tooth and an implant, and at least 3 mm between two implants. The choice of the diameter of the implant ensues directly from this constraint.

Thus, for instance, for the replacement of a premolar of a 7 mm mesio-distal diameter between two natural teeth, a 4 mm implant will be chosen. The axis of the implant must correspond to the bisector of the angle formed between the two adjacent teeth. Ideally, the axis should pass beside the most

apical point of the neck ; this will then facilitate the restitution of more natural transition lines.

- **Buccal-palatal direction** : it is mostly the buccal side which has a tendency to resorb⁶. Around the natural tooth, this side is the finest and thus suffers most from the loss of desmodontal vascular supply coming with avulsion. The position of the implant should allow a 2 mm minimum vestibular bone thickness. This axis, to allow the choice of the assembly mode, must be sufficiently rectified to provide for a cingulum emergence for the anterior teeth, at the bottom of an intercuspidian groove for cuspidate teeth.

- **Vertical direction** : it is certainly the most complicated part to come to grips with because vertical positioning depends both on the kind of implant (conventional or with platform switching) and the desired goal. In non-aesthetic sectors, it is not always necessary to align the necks. The vertical position then depends on the available bone volume. In aesthetic sectors, vertical positioning must be more accurate and be chosen based on the desired clinical neck of the planned prosthesis and not the available bone volume. To do so, one should, from the chosen clinical neck, add the sulcus depth which is variable and the height of the biological space. The bone should be located 5mm on average from the neck. The surgeon must understand, based on the kind of implant that is used, how to position the implant in the vertical direction. For conventional implants, the bone is located at the juncture between the smooth part and the rough part of the implant. For implants with a switching platform, the platform of the implant will be buried 1 mm beneath the bone level. In fact, when the virtual patient representation is obtained by the computer based superimposition of the planned prosthesis and imaging, the position is no longer defined by the above-mentioned 3 directions but by 3 other factors which are more oriented towards the surgical gesture, namely :

- A point of emergence
- An implant axis
- Vertical positioning

These three factors correspond exactly, in that order, to the questions that are raised during the fitting of an implant. First one needs to determine the drilling point by marking it lightly with the tip of the bit. Then, from this first point, orient the drill by adequately positioning the head of the contra-angle. Finally stop drilling at the determined depth, while making sure to drill enough to be able to screw the implant in its predetermined position

The picture shows a patient who lost 21, 22 and 23 after a fall. The goal of the treatment is to place two implants in 21 and 23 to then make an implant-supported bridge that will be screw-retained on zirconia/ceramic on titanium bases. Even if one is trained and fully knows the rules of positioning, without a guide, the accuracy and reproducibility of the positioning are variable⁷.

It is highly recommended to use static and dynamic guiding systems to optimize the position of the implant and thus apply at best the criteria necessary for the success of prosthesis implant treatment^{8,9}.

IMPLANT AXIS AND DENTAL PROSTHETIC AXIS

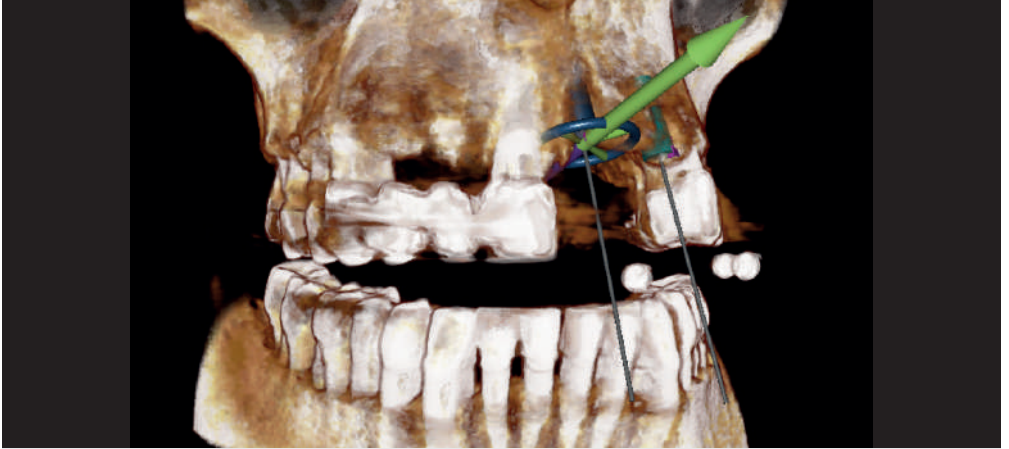


Fig 1: Without prosthetic reference, giving the accurate three-dimensional positioning of implants is extremely uncertain

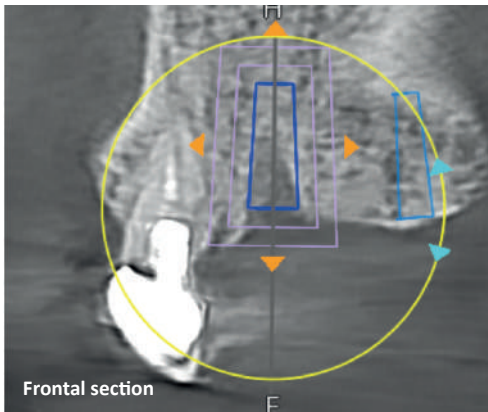
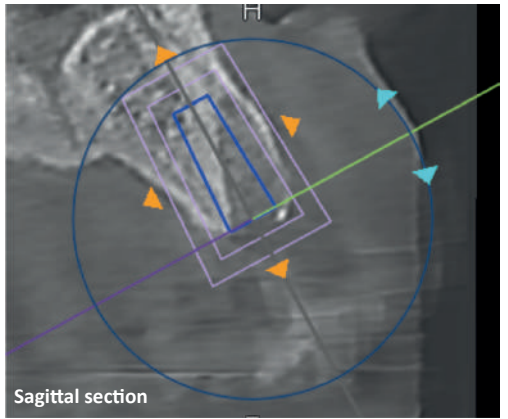
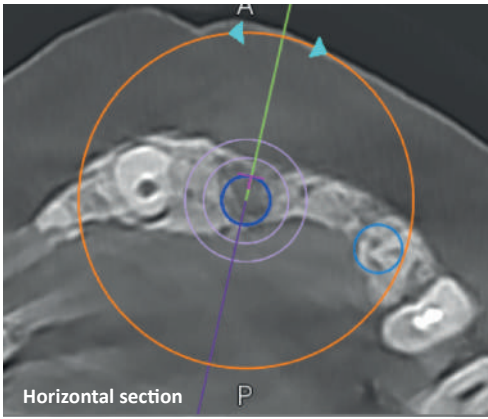


Fig 2:
Without prosthetic reference,
it is impossible to define any position
in any of the three dimensions

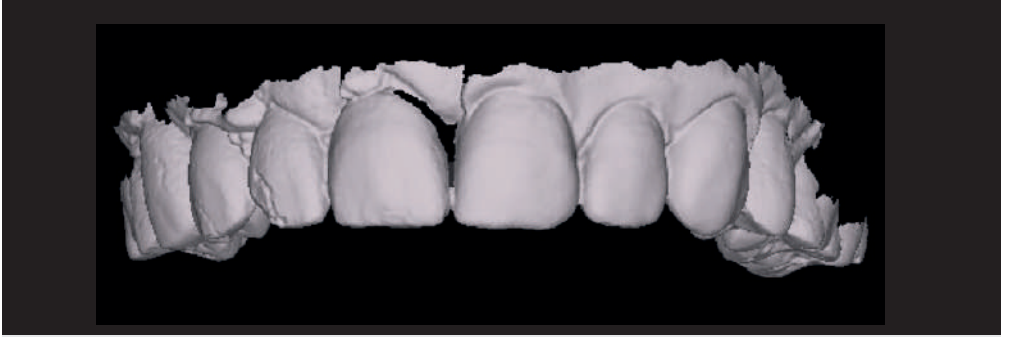
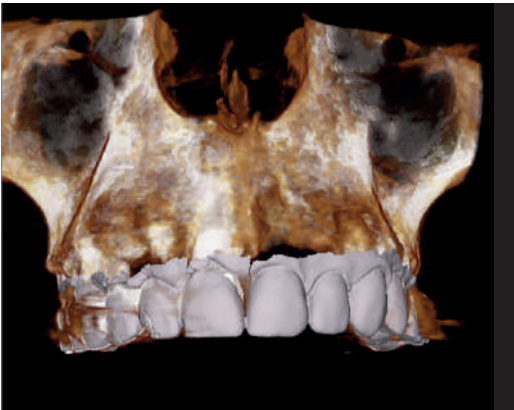
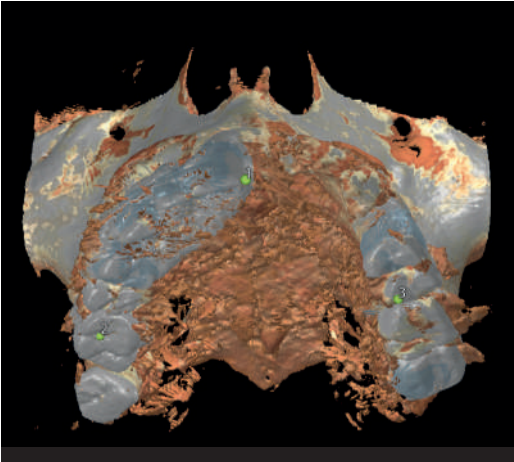


Fig 3 : STL file of the maxillary arch and the planned prosthesis



*Fig 4 :
The DICOM file of three-dimensional imaging (CBCT)
and the STL file are superimposed thanks to match points*

IMPLANT AXIS AND DENTAL PROSTHETIC AXIS

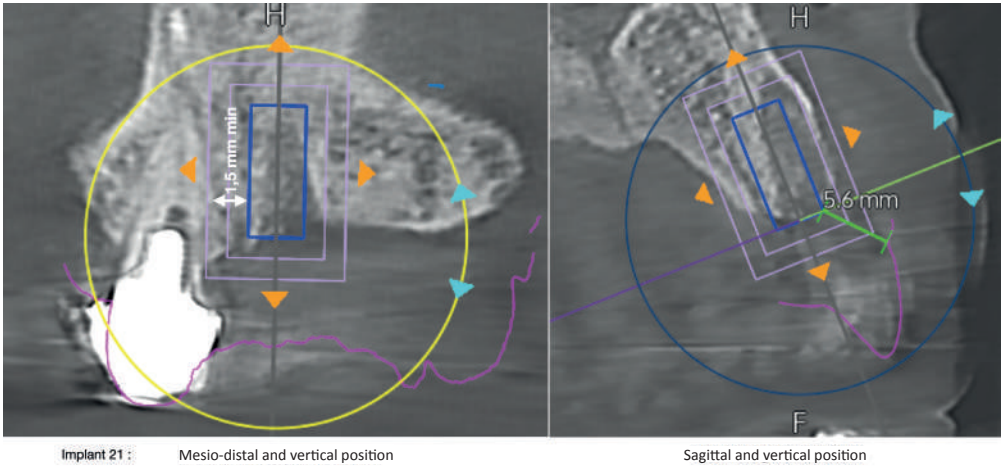


Fig 5 : Implant in 21 is planned according to prosthetic contours colored here in magenta. The positioning respects the rules decided upon earlier

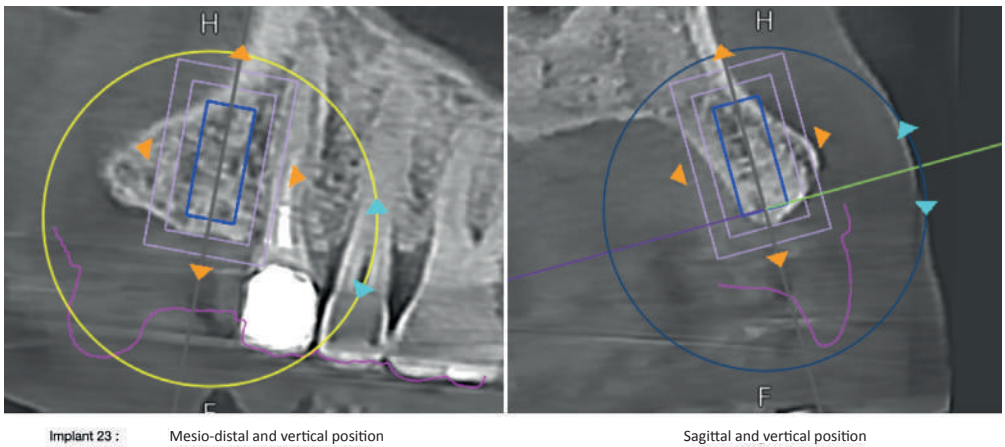


Fig 6 : Implant in 21 is also planned. It is interesting to note the proximity of its apex to labial cortical. The vertical positioning allows enough bone thickness at the crestal level to ensure its trophicity, and in the end to enable the realization of a screw-retained crown. Thus this position is perfect both biologically and prosthetically.

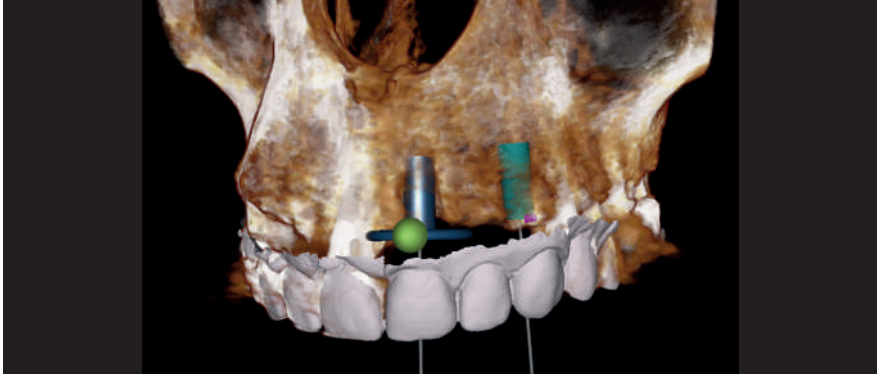


Fig 7 : Graphic representation of implant position.

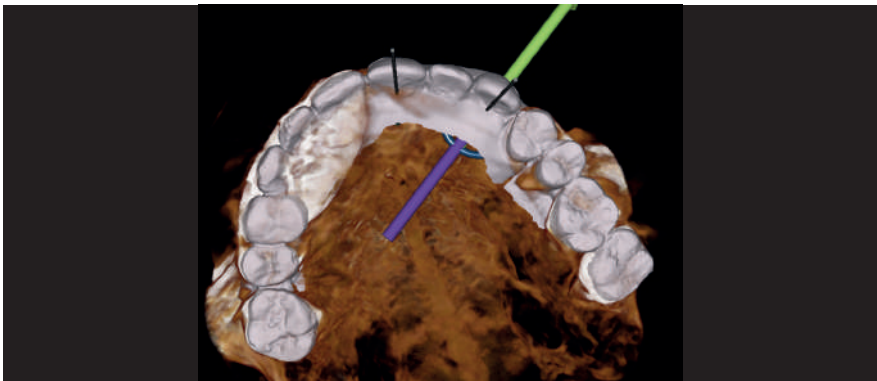


Fig 8 : Occlusal view showing the emergence of implant axes in the prosthetic project.

Conclusion

An implant should be considered as an apical extension of the future prosthetic restoration and not the contrary. It is placed according to the prosthesis plan and not merely the bone tissue situation. The aim is not to fit the longest implant possible. The aim is to obtain a perfect implant/prosthesis relation. When the bone volume is not conducive to an ideal implant position, an intervention on the bone is required, by addition most often, sometimes by subtraction (to align the necks for instance). The aesthetic and functional integration of an implant-supported prosthesis, the trophicity and the stability of peri-implant tissues, the possibility to have efficient oral hygiene and easy maintenance : that is what is at stake in well-thought out and well-executed implant positioning.

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