Applications of Biomaterials

Dental Implants, Distraction Osteogenesis Biomaterials

BIOMEDICAL DESIGN FOR IMPROVING THE PREMIER STABILITY OF DENTAL IMPLANTS

materials including human and animal teeth, carved bone, pieces of ivory, and pearl. The apparent purpose for such attempts at tooth replacement was purely esthetic. In terms of chewing function, they were worthless.

- the transplantation of teeth was fashionable in the higher social circles,

- implantation of alloplastic materials (rubber, gold, porcelain, etc.) shaped to resemble tooth roots,

- Needle implants, inserted into the nobe of the jaws as dipods, tripods or arranged in a row.

- Linkow in 1968, introduced implants in the shape of special blades [12].

- In an attempt to film the microcirculation of rabbit bones, Branemark noticed that the metallic cap at the end of a fiber optic cable embedded in the bone of an experimental animal had apparently become fused to the bone after remaining in situ for some days.

Branemark observation led him to postulate that the metal of the end cap, namely Titanium, had properties that could be valuable in the construction of dental implants.

2.1 Endosteal

- 2.1.1 Root Forms (Press-fit, Self-tapping , Pretapping (threaded) implants),
- 2.1.2 Blade Implants (Prefabricated, custom-cast and alterable),
- 2.1.3 Ramus Blade and Ramus Frame,
- 2.1.4 Transosteal Implants,
- 2.1.5 Crete Mince (These are threaded, self-tapping titanium spinals).

2.2 Subperiosteal

- 2.2.1 Complete, Universal, and Unilateral (These are always custom-made).,
- 2.2.2 Caveat (Extremely thin (pencil-like) mandibles and maxillae may permit).

2.3 Endodontic Stabilizer (they are placed into bone through the apices of natural teeth to stabilize mobile teeth).

2.4 Intramucosal Inserts (buttonlike non-implanted retention devices to stabilise dentures)

3. ANATOMIC FACTORS OF JAW BONE

3.1 Bone Quality;

Classification of the various bone qualities was proposed in 1985 by Lekholm and Zarb [13].

Class I ; Jaw consists almost exclusively of homogeneous compact bone
Class II ; Thick compact bone surrounds highly trabecular core
Class III ; Thin cortical bone surrounds highly trabecular core
Class IV ; Thin cortical bone surrounding loose, spongy core

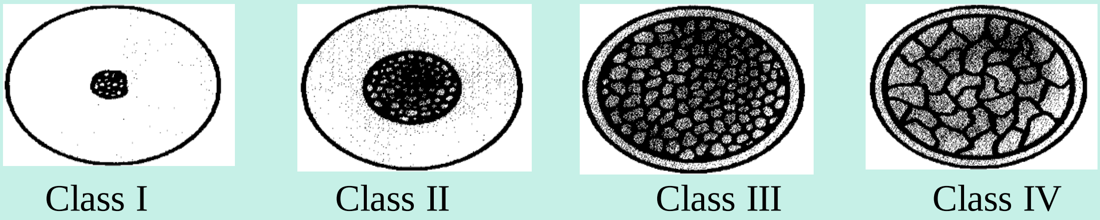


Figure3.1 Classification of various bone qualities [13].

3.2 Bone Quantity

3.2.1 Height of Bone

The vertical extent of bone available for implantation is defined by the distance between the alveolar crest and opposing anatomic boundaries (e.g., sinuses, mandibular canal, etc.). Implants should be placed with a safety margin of 1-2 mm from such structures.

3.2.2 Width of Bone

The width of bone is measured in the area of the planned implant placement site as the distance between the oral (lingual, palatal) and the vestibular (buccal) osseous walls at the level of the alveolar ridge.

3.2.3 Length of Bone

The minimum distance as measured from axis to axis between two implants is 7 mm. Depending on the implant diameter, this corresponds to a minimum 3-4 mm distance between implants. The minimum distance between implant and a tural tooth should be about 1.25 mm.

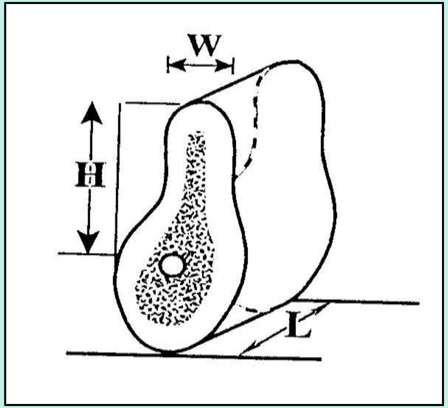
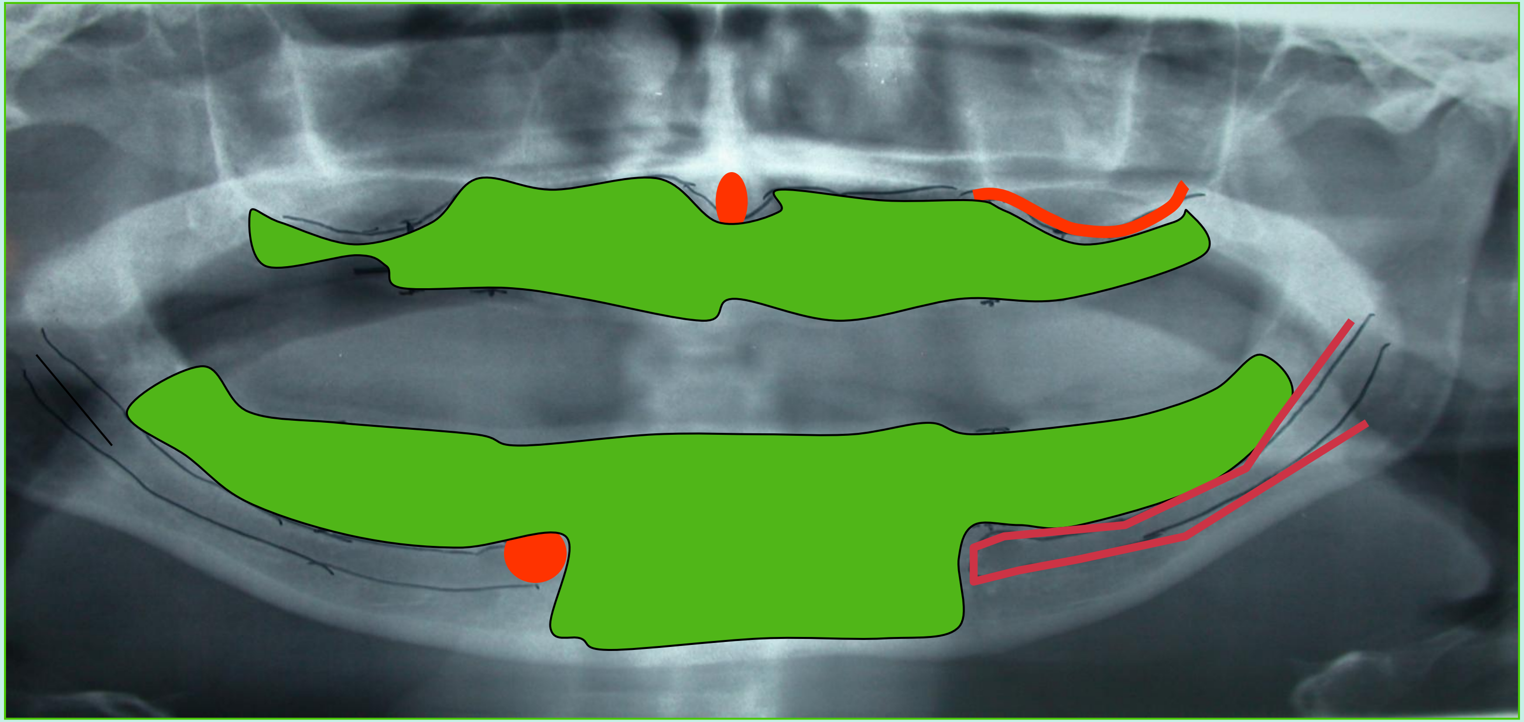


Figure3.2
Sectional drawing of mandibular bone showing the length, height and width[92].



“Direct functional and structural connection between living bone and the surface of a load bearing implant..Albrektsson [20].

“A process in which a clinically asymptomatic rigid fixation of alloplastic material is achieved and maintained in bone during functional loading“ Zarb & Albrektsson [21] .

Branemark [22] suggested definitions from various viewpoints;

From the viewpoint of the patient an implant fixture is osseointegrated if it provides a stable and apparently immobile support of prosthesis under functional loads, without pain, inflammation or loosening over the lifetime of the patient.

From a viewpoint of macroscopic and microscopic biology if at light microscopic level, there is no interpositioned connective or fibrous tissue and that a direct structural and functional connection is established, capable of carrying normal physiological loads without excessive deformation and without initiating rejecting mechanisms.

From a macroscopic biomechanical point of view a fixture is osseointegrated if there is no progressive relative motion between/the fixture and surrounding living bone and marrow under functional levels and types of loading for the entire life of the patient.

From a microscopic biophysical point of view osseointegration implies that at light microscopic and electron microscopic levels, mineralized tissue is found to be in contact with the fixture surface over

4.1 Mechanism of Osseointegration

In order for optimal bone formation to occur a coordinated series of events ranging from protein adsorption to osteoid synthesis and calcification must take place. In general categories these events can be summarized as;

4.1.1 Protein adsorption

4.1.2 Cellular adherence

4.1.3 Local factor production

4.1.4 Differentiation

4.1.5 Matrix production

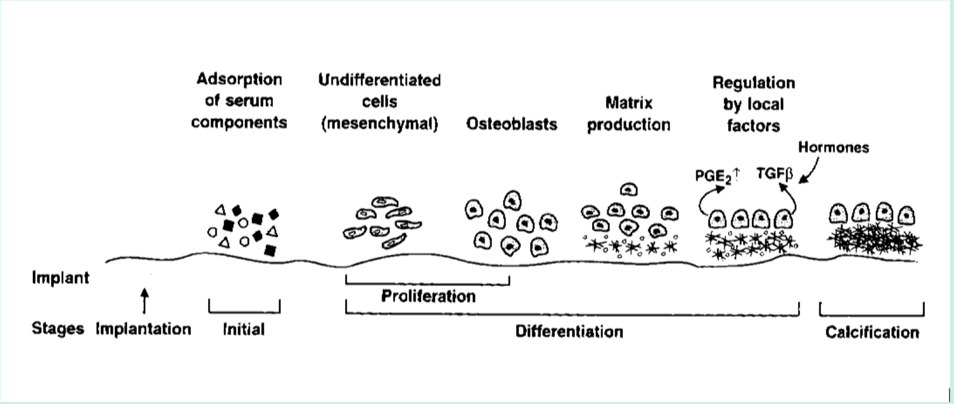


Figure 4.1 Series of events ranging from protein adsorption to osteoid synthesis and calcification for optimal bone formation[25].

5. CRITERIA FOR SUCCESS AND FAILURE IN IMPLANTOLOGY

At the last NIH/AAP concencus conference in Bethesda, the following success criteria for an endosseous implant were proposed (Steenberghe) [33];

- Do not cause allergic, toxic or gross infectious reactions either local or systemic,
- Offers anchorage to a functional prosthesis,
- Does not show signs of fracture or bending,
- Does not show any mobility when individually tested by tapping or rocking with a hand instrument, or when tested with an electronic tapping device does not reach improper values of rigidity,
- Does not show any signs of radiolucency on an intra oral radiograph using a paralleling technique strictly perpendicular to the implant-bone surface.

5.1.1 Pain; Absence of pain under vertical and horizontal forces is a primary implant criterion of evaluation.Pain or discomfort is often associated with mobility and could be one of the first signs which indicate an implant failure [34].

5.1.2 Sound; It has been suggested that a subdued sound upon percussion is indicative of soft tissue encapsulation, whereas a clear crystalline sound indicates successful osseointegration.

5.1.3 Bleeding Index ; Healthy sites were characterized by complete absence of bleeding on probing, whereas both peri-implant mucositis and peri-implantitis sites showed significant bleeding. The reason for these differences might be attributed to the different probing forces used (0.5 N versus 0.2 N, respectively). However, recent findings [41] also reported by Esposito [42] suggested that bleeding can not be used as discriminator of a healthy or diseased peri-implant state.

5.1.4 Probing Depths ; Implant shape, design and surface texture may influence probe tip penetration and occasionally, even render clinical probing impossible. Also underestimation of probing depth may result. Hence it must be anticipated that clinical probing may not result in reliable assesments in all implant systems [46].

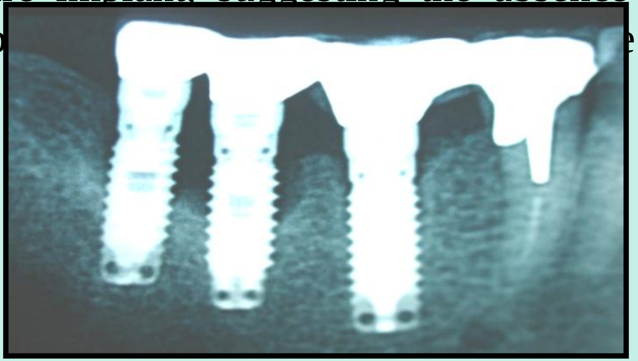
5.1.5 Mobility and Rigid Fixation ; One of the clear sign of implant success and failure is

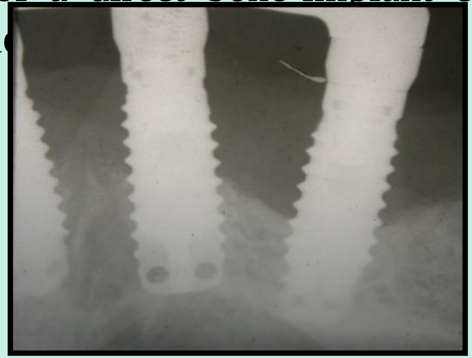
5.2 Radiological Evaluation

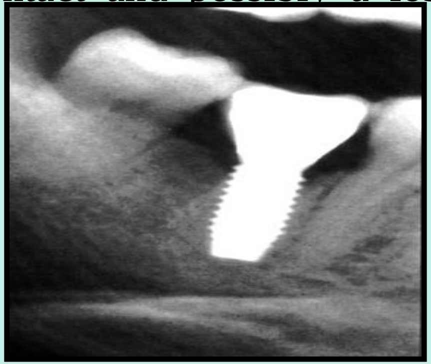
An absence of radiolucency around an implant does not mean bone is present at the interface, especially in the anterior mandible. As much as %40 decrease in the trabecular bone is necessary to produce a radiologically evident difference in this region, because of dense cortical bone [50].

However the presence of a radiolucent region around implant definetely represents the presence of fibrous tissue. There seems to be unanimous consensus that progressive marginal bone loss is a pathological sign which can lead to implant failure.

There can be 2 well-distinct radiographic pictures: a thin peri-fixtural radiolucency surrounding the entire implant, suggesting the absence of a direct bone-implant contact and possibly a loss of stab ... e le







5.4.1.1 Endogenous factors

1. Systemic
   a. Patients with compromised medical status
   b. Smoking patients (more then 10 per day)

2. Local
   a. Irradiation therapy
   b. Poor bone quality/quantity
   c. Bone grafting
   d. Parafunctions

5.4.1.2 Exogenous factors

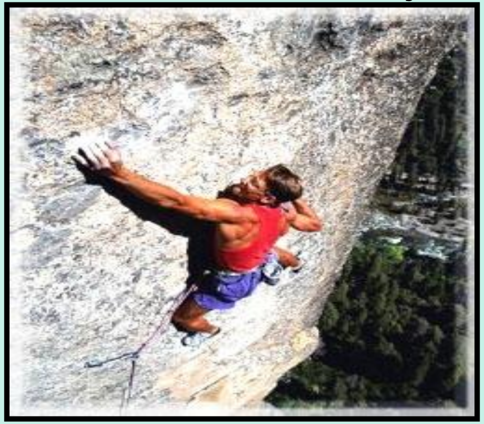
1. Operator-related
   a. Non-optimal operator experience
   b. High degree of surgical trauma
   c. Bacterial contamination
   d. Immediate loading
   e. Non-submerged technique
   f. Non-optimal number of supporting implants

2. Biomaterial-related
   a. Non-optimal surface properties
   b. Non-optimal implant design

Early micromotion can lead to differentiation of cells into fibroblasts and inhibition of bone growth. Newly formed supporting bone can lead to differentiated, after 4 weeks of healing, into connective fibrous tissue, when an unstable mechanical situation is induced [59]. Such tissue differentation was found to be partly reversible after a relative stabilisation of the screws. In another experimental study, in which micromotion was discontinued between 4 and 16 week, the fibrous tissue surronding Ti and HA coated implants was replaced by bone.

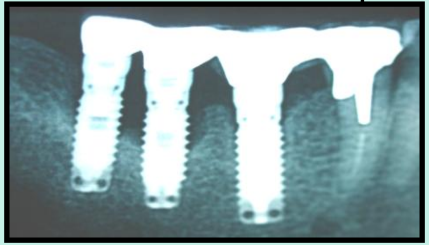
The publication of Matsuo [60] by giving the 14, 30, and 120 day histologic results have shown the complexity of the healing mechanism around implants and the micromotion will demage the healing capacity . Another information about the surface difference was given also by the same group; saying the microcirculation is created in 7 days around TPS ipmlants whereas we need 14 days for Ti implants.

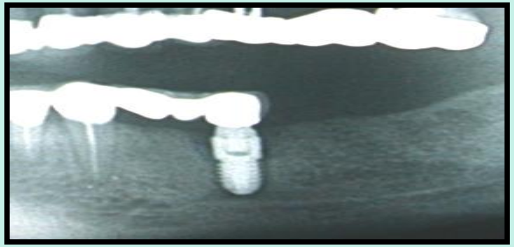
The first two weeks of the bone healing after implant surgery is very essential and the micromotion may not be tolerated which can end up with fibrocapsulation of the implant.



It has been stated that overloading of an oral implant can result in loss of the marginal bone or complete loss of implants where osseointegration has been achieved [7, 61, 62]. The most convincing evidence for this theory, so far, has been presented by Sanz in 1991 [63]. In 6 patients who had implants with mobility and peri-implant radiolucency or marginal loss but without pockets exceeding 3 mm and without bleeding. They found healthy peri implant mucosa without the signs of inflammation in light and electron microscobe evaluations. This result was interpreted by authors to mean that overload had caused the peri-implant breakdown.

Thus «occlusal trauma in oral implantology described as ; the clinical situation when the loading on implants exceeds the physiological range of bone adaptation which may then cause loss of osseo-integration by replacement of the bone-implant interface with a soft tissue layer or/and resorption of bone at a short distence from the implant surface.





Occlusal overload on oral implants can result in complete or partial loss of osseointegration.
Implants with plaque accumulation, on the other hand, may show signs of peri-implantitis with a

unfavorable from a biomechanical point of view have increased the number of complications[65].

7.2 Number of Implants ; The implants replacing the natural tooth, especially in posterior region are under heavy occlusal forces, so it’s evident that replacing each teeth with one implant is better. Nowadays there is a new concept of replacing molars with two implants, sceintific data is not avaliable yet for this concept.

7.3 Crown Root Ratio ; The greater the distance from the point of occlusal contact to the abutment-fixture connection, the higher the bending moment which will be induced by a transverse force[70].

7.4 Axial Forces ; It is important to strive at minimizing functional bending moments in implant-supported prostheses [71]. Forces should preferably be directed axially.(perpendicular to the crown)

7.5 Rigid Connection Between Teeth and Implant; The periodontal ligament is missing at implants;

8.1 Implant Type ; Tested with a removal torque test, $Ti0_2$ blasted and plasmasprayed implants have shown better anchorage in bone than implants with only a machine-produced surface[83, 84]. . The implant design and surface characteristics plays a role in the implant surface area, which will relatively affect the loading concepts. There is a table given showing how the surface area changes with implant design.

8.2 Implant Lenght ; Retrospective studies and reviews have indicated that shorter implants fail more frequently than longer ones [85]. The consequence of using short implants is a reduced amount of mineralised bone to implant contact to stabilize the implant, and in regions of poor bone quality studies have shown increased failure rates [86].

8.3 Implant Diameter ; Implant diameter is also important in prothetic concept, as it was also important in osseointeration concept. The reason is that most standard implant types have cervical diameters from 3.5 mm to 5 mm, corresponding to the approximate mesiodistal dimension of natural premolars in the cervical/subgingival area. But this diameter does not correspond to the average mesiodistal or vestibulolingual size of the natural teeth. Premolar units would then give the best contoured prosthetic replacements. Furthermore, if the distance between the two implants is too small, there will be problems with the use of instruments and/or with oral hygiene.

A number of published reports have recommended using wider implant diameter if the jaw is wide

The surface area of implant will increase by wider diameters, longer implants and with rougeous surfaces. So the Ante’s Law in prostetic fixed restorations which says ; « the root surface area of the abutment teeth must be larger then the surface area of the teeth missing ». So its useful to keep in mind the surface area comparisons of different surface, lenght and diameter implants.

Spline Implant Body Surface Area		
Implant	**Implant Length (mm)**	**Surface Area (mm²)**
3.25mm Cylinder	8	89.0
	10	109.3
	13	139.8
	15	159.8
	18	189.8
4.0mm Cylinder	8	110.8
	10	136.0
	13	174.0
	15	198.9
	18	236.3
5.0mm Cylinder	8	148.3
	10	181.9
	13	229.1
	15	260.6
3.75mm Threaded	8	110.4
	10	144.9
	13	196.5
	15	231.0
	18	282.2
5.0mm Threaded	8	170.4
	10	217.7
	13	286.5
	15	331.3

Table 8.1 Surface area of dental implants with diameter and length[86]

9.1 Tooth Parts

9.1.1 The crown

9.1.2 Enamel

9.1.3 Dentine

9.1.4 Pulp

9.1.5 The roots

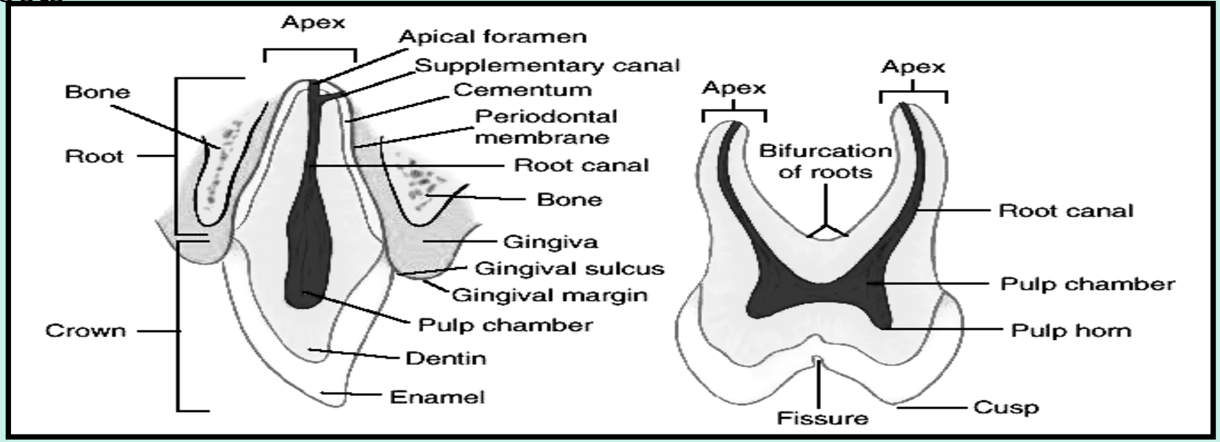
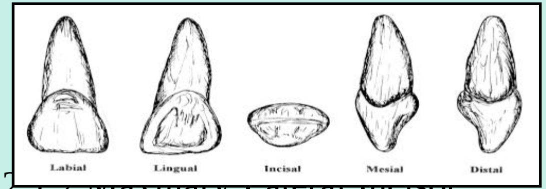


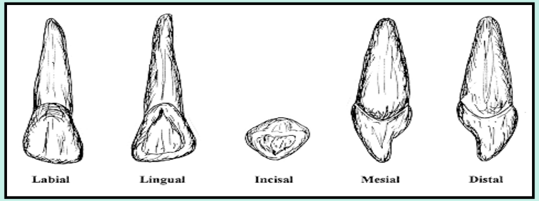
Figure 9.2 Drawing of teeth parts and structure[92].

9.2.1 Adult Incisors

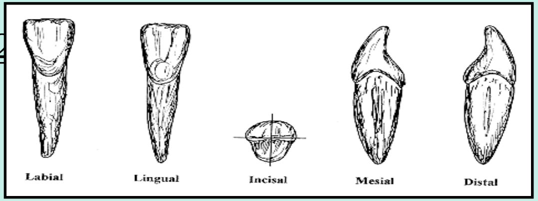
9.2.1.1 Maxillary Central Incisor



9.2.1.2 Maxillary Lateral Incisor



9.2



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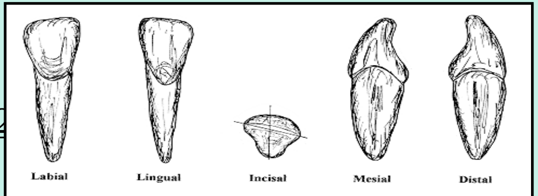
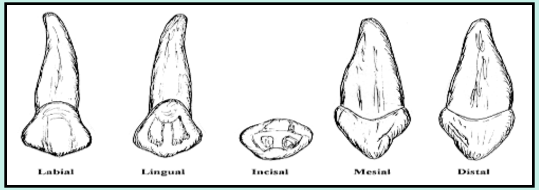
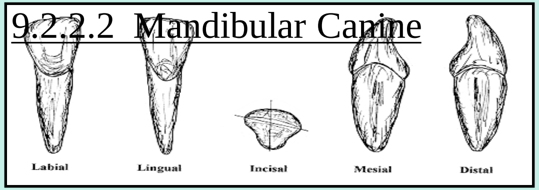


9.2.2 Adults Canines

9.2.2.1 Maxillary Canine

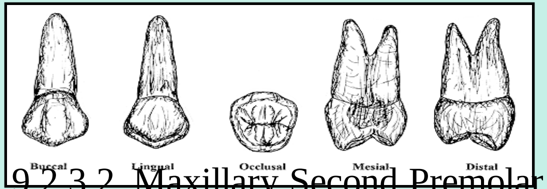


9.2.2.2 Mandibular Canine

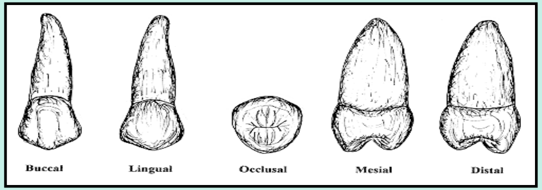


9.2.3 Adult Premolars

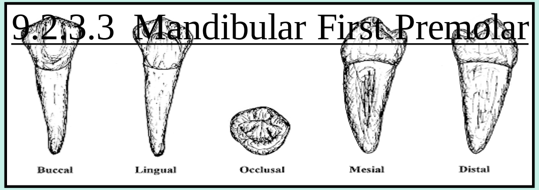
9.2.3.1 Maxillary First Premolar



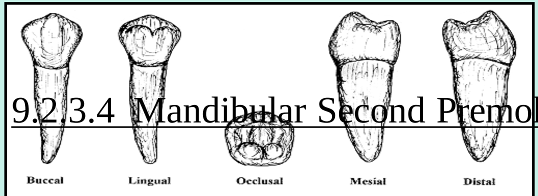
9.2.3.2 Maxillary Second Premolar



9.2.3.3 Mandibular First Premolar

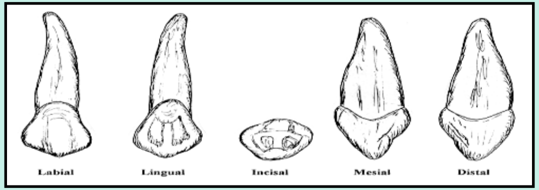


9.2.3.4 Mandibular Second Premolar

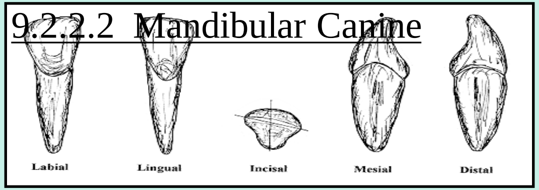


9.2.2 Adults Canines

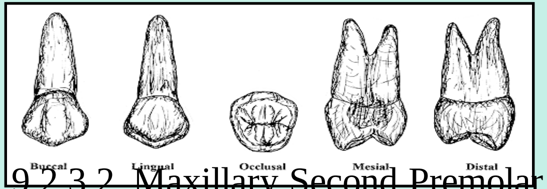
9.2.2.1 Maxillary Canine



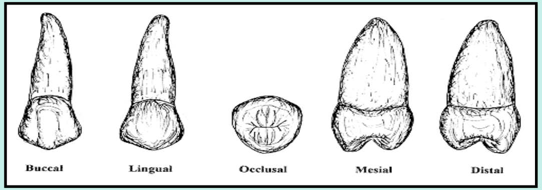
9.2.2.2 Mandibular Canine



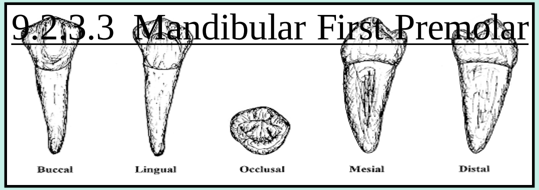
9.2.3.1 Maxillary First Premolar



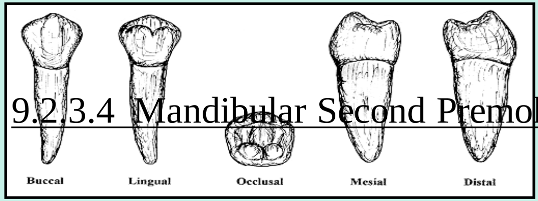
9.2.3.2 Maxillary Second Premolar



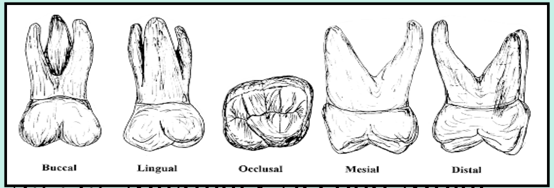
9.2.3.3 Mandibular First Premolar



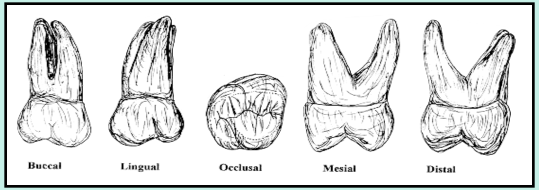
9.2.3.4 Mandibular Second Premolar

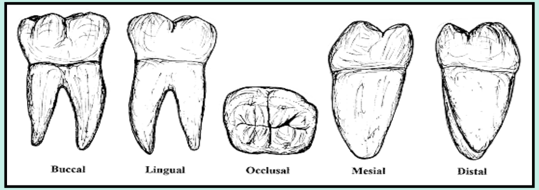


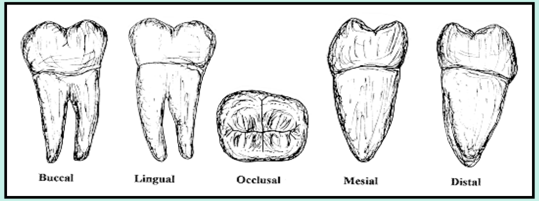
9.2.4.1 Maxillary First Molar



9.2.4.2 Maxillary Second Molar



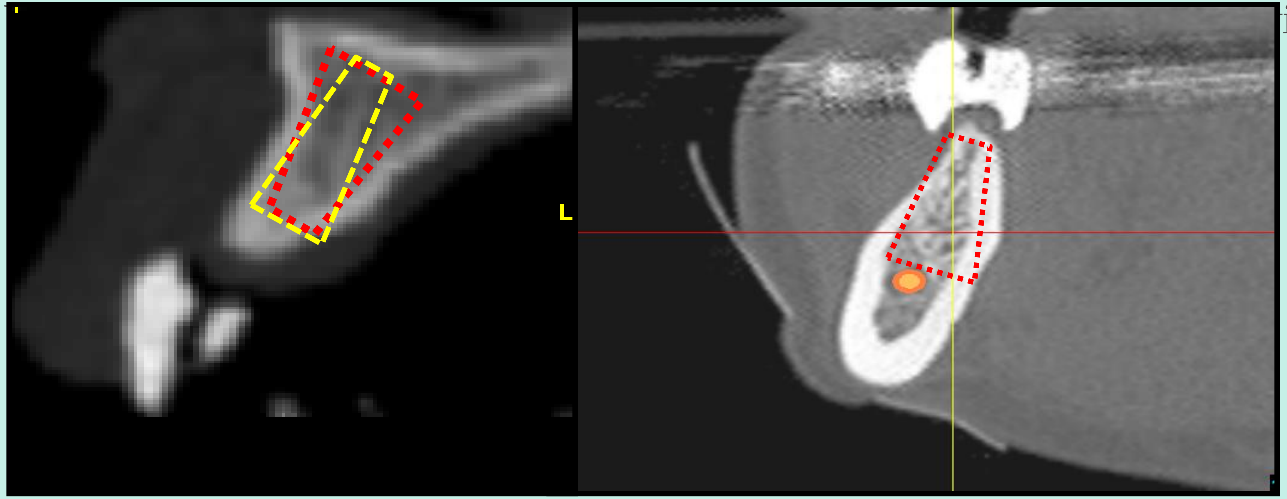




10. COMPARISON OF TOOTH MORPHOLOGY WITH IMPLANTS

In previous chapter we have deeply made the analysis of the tooth anatomy and morphology. Since with dental implants we are aiming to replace the missing function of the teeth and missing estehetic of the teeth; we have to compare the anatomical structures and find the most appropriate modeling for the implant design.

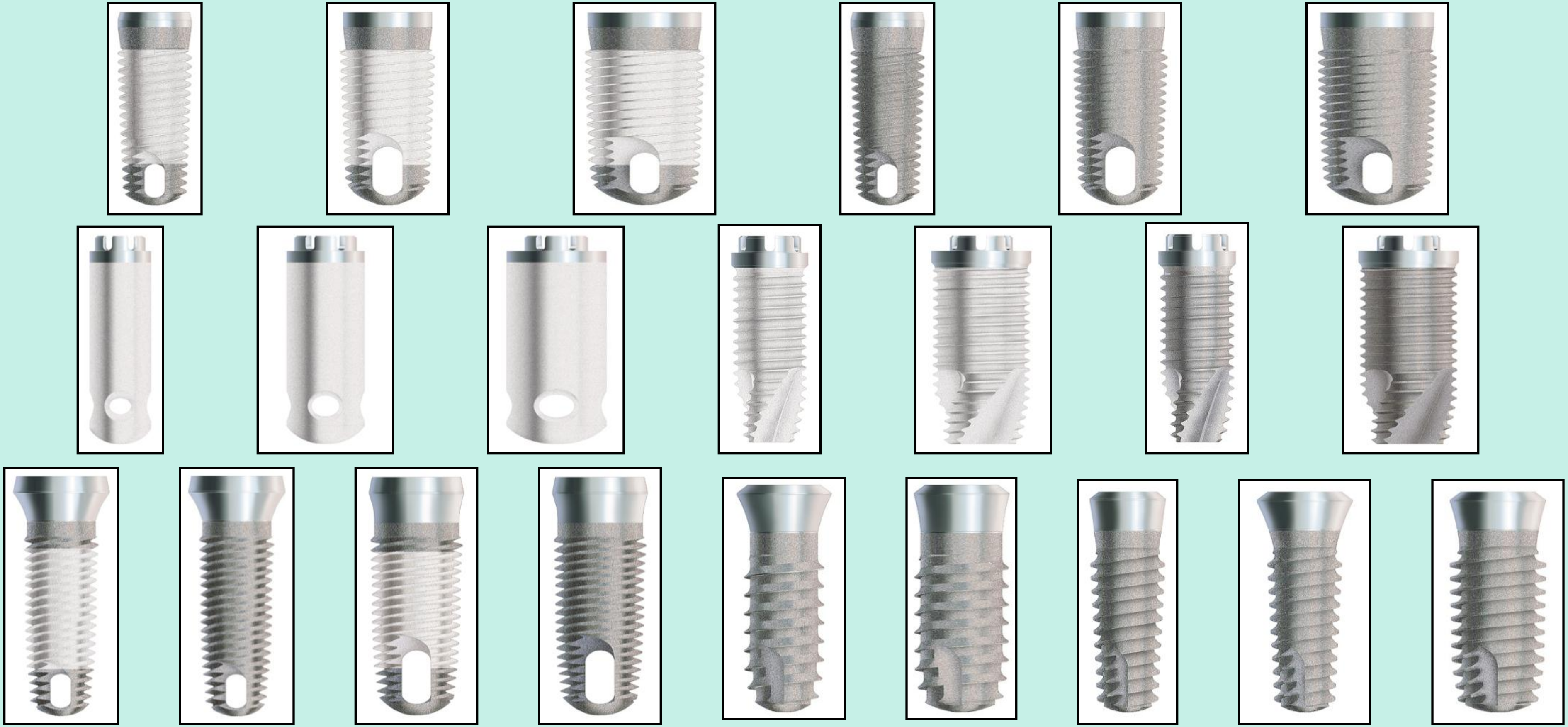
Implants are placed in jaw bones where previously tooth was extracted or not developed congenitally. So the bone structure to recieve the implant fixture is narrow coronally and wider apically.



ing image.

Figure 10.1 Sectional CT view of maxillary and mandibular bone showing the length, height and width.

Spline/Centerpulse Implants and Surface enhancements



A prototype is an original type, form, or instance of something serving as a typical example, basis, or standard for other things of the same category.

11.1. Basic prototype categories

11.1.1 Proof-of-Principle Prototype; Also called a breadboard. This type of prototype is used to test some aspect of the intended design without attempting to exactly simulate the visual appearance, choice of materials or intended manufacturing process.

11.1.2 Form Study Prototype; This type of prototype will allow designers to explore the basic size, look and feel of a product without simulating the actual function or exact visual appearance of the product. They help assess ergonomic factors, provide insight into visual aspects of the final form.

11.1.3 Visual Prototype ; This group will capture the intended design aesthetic and simulate the appearance, color and surface textures of the intended product but will not actually embody the function(s) of the final product. These models will be suitable for use in market research, executive reviews and approval, packaging mock-ups, and photo shoots for sales literature.

11.1.4. Functional Prototype ; Also called a working prototype will, to the greatest extent practical, attempt to simulate the final design, aesthetics, materials and functionality of the intended design. The construction of a fully working full-scale prototype and the ultimate test of concept is the

11.3.1 Advantages of prototyping

- May provide the proof of concept necessary to attract funding
- Early visibility of the prototype gives an idea of what the final system looks like
- Encourages active participation among users and producer
- Enables a higher output for user
- Cost effective (development costs reduced)
- Increases system development speed
- Assists to identify any problems with the efficacy of earlier design and coding
- To refine the potential risks associated with the delivery of the system
- Various aspects can be tested and quicker feedback can be got from the user
- Helps to deliver the product in quality easily
- User interaction available in during development cycle of prototype

11.3.2 Disadvantages of prototyping

- Producer might produce a system inadequate for overall organization needs
- User can get too involved whereas the program can not be to a high standard
- Structure of system can be damaged since many changes could be made
- Producer might get too attached to it (might cause legal involvement)

The model development was first started with the search of appropriate software to be used to design the model. With the consultations and the search carried through the solid material designing software or surface designing softwares were found relatively appropriate to carry the study. First of all courses on Alibre Design software was taken from MTM Computer Ltd to develop personal knowledge and capabilities to use designing softwares. Personal development courses were taken to be able to better understand the limits of designing. Furthermore due to the limited time allocated fort his research, instead of using the limited time for learning the use of software aplications support was taken from Mr. Hrant Arzumanyan for applying the developed ideas to the computer aided designed model at Rhino Software. The starting point of the design was to mimic the classical implant model of

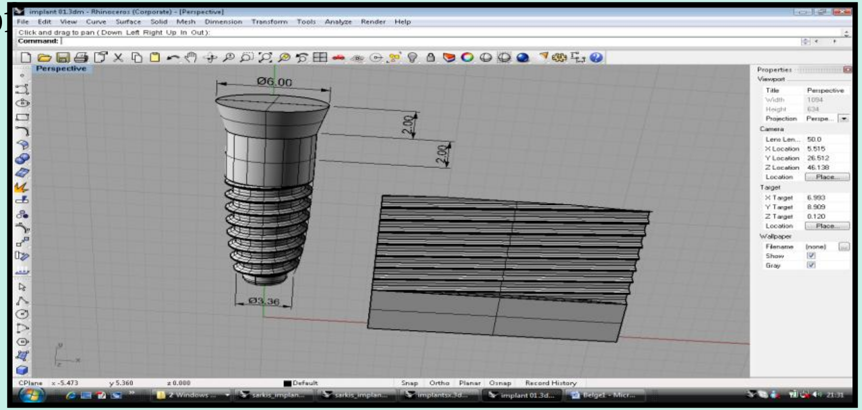


Figure 12.1 Model development in 3D designing software.

Then development of the apical portions to increase the stability was realised. The preliminary designs were not sophisticated and not found to be logical in terms of clinical application and also production of such a model was very complicated, thus would not be a model proposed rather then a research subject. As we have studied very carefully the tooth structure and morphology in previous chapters, especially in posterior regions where bone quality is not good, the shape of premolar or molar tooth would be a very good model to develop. The molar teeth has two or three roots depending on the region of the jaw bone, but both with having a furcation and seperate roots has more stability in bone rather then one rooted teeth. That’s why we have studied the possibility of a

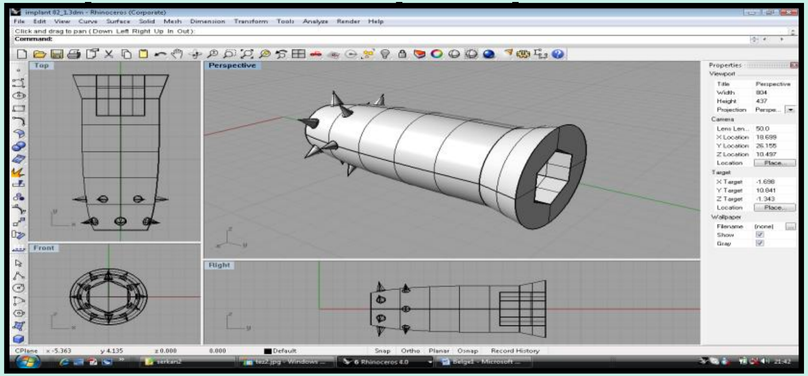


Figure 12.2 Model development in 3D Designing software.

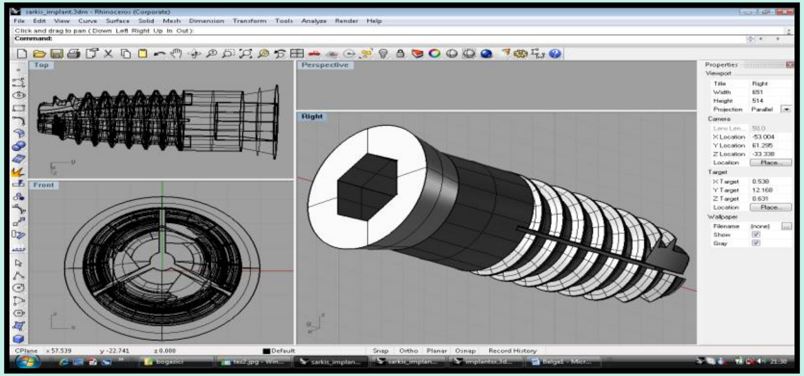


Figure 12.3 Model development in 3D Designing software.

12. PRODUCTION OF PROTOTYPE

The conical implant design is cut to three portions in the apical part of the material to be seperated to mimic the three rooted structure of the molar teeth. It is easier to shape a titanium implant exactly as tooth with three roots. But the difficulty is the implant site prepereation for such a model. Because the bone structure is very narrow mostly and to open a big insertion hole will cause complications on the osseointegration. The ideal but also the difficult aspect is to design such a model that will enter the prepared bone site in a conical shape and then change its shape to a three

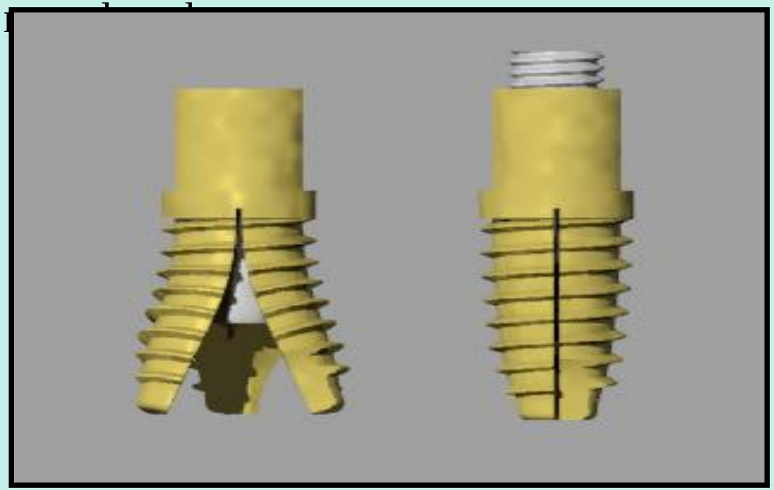


Figure 12.4 Drawing of developed model apical arms open and apical arms close.

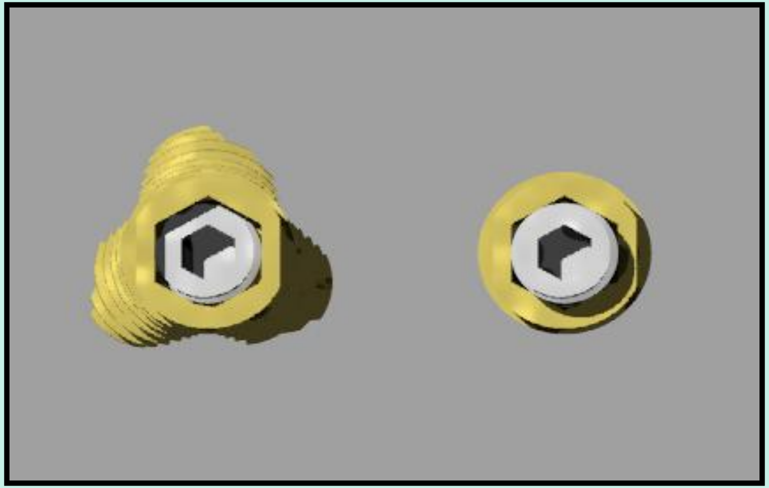


Figure 12.5 Drawing of developed model apical arms open and apical arms close. (Occlusal view)

That's why design was developed in the apical portion with three cuts, which will anable the move of the apical portions externaly. This movement will reshape the implant inside the bone in a three rooted form which we believe will increase the premier stability of the dental implant.

This was studied in different manners to find the most appropriate approach to find the method to expand the apical root portions of the implant design. It's possible to tap some sizes of pins to open the apical arms, but this would be an irriversible action where we have no control

But afterwards we have developed the design with transvertical passing screw to open the apical a … he d … the
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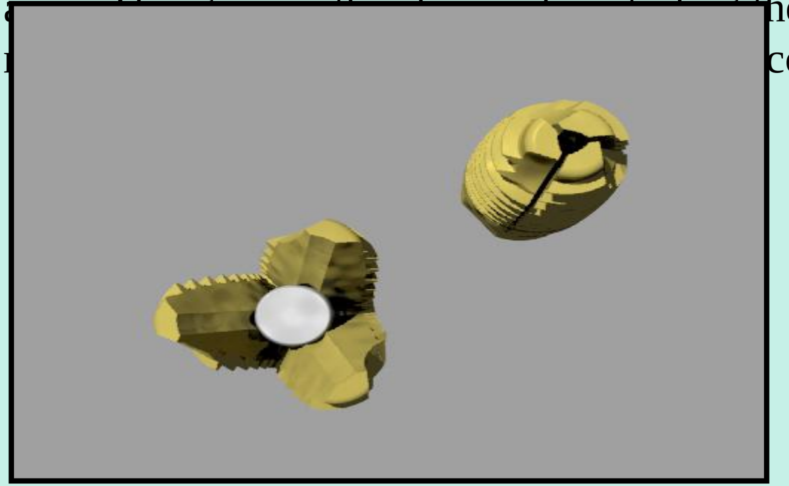


Figure 12.6 Drawing of developed model apical arms open and close. (Apical view).

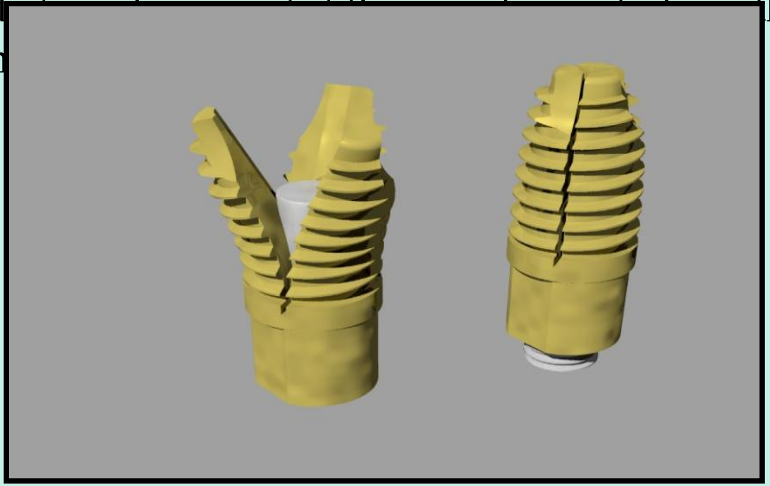


Figure 12.7 Drawing of developed model apical arms open and close. (Lateral view)

12. PRODUCTION OF PROTOTYPE

The design is then worked in detail in Rhino Ceros software to precisely adaptation of the pieces and also prepared for casting processes.

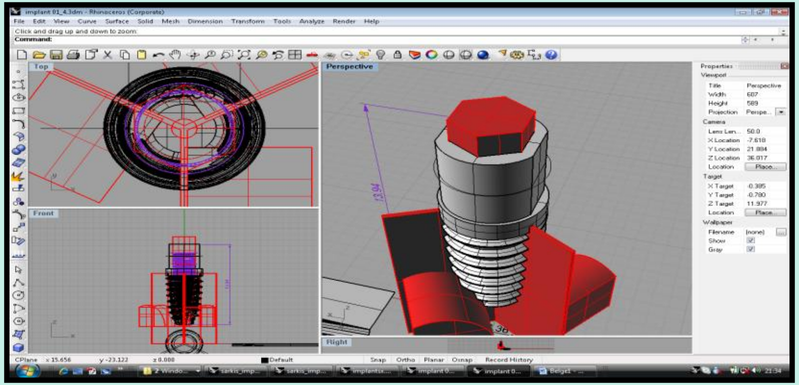


Figure 12.8 Model apical portions sectioning the extension pieces

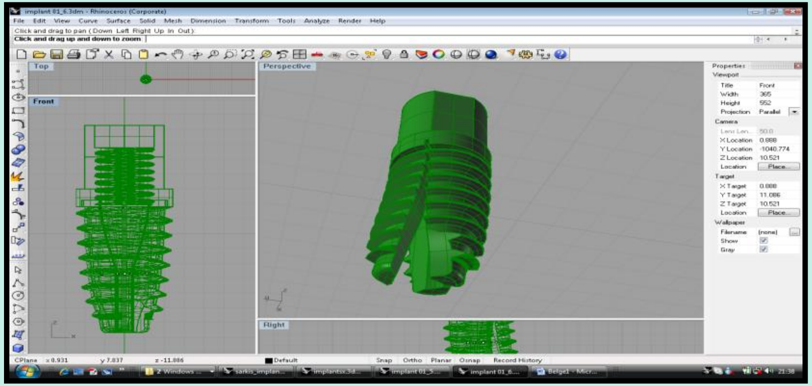


Figure 12.9 Model apical portions controlling of the extension pieces

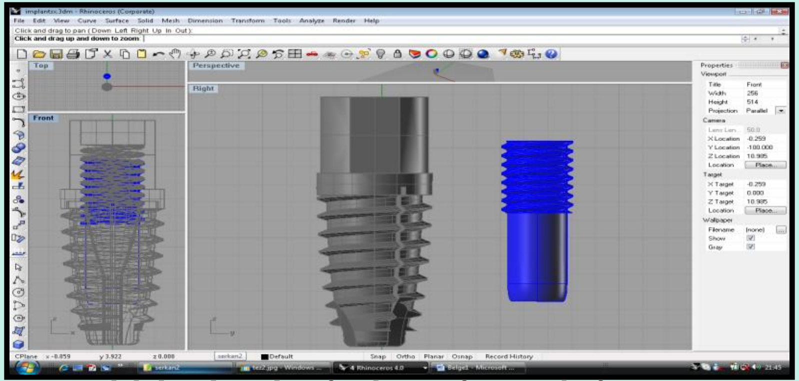
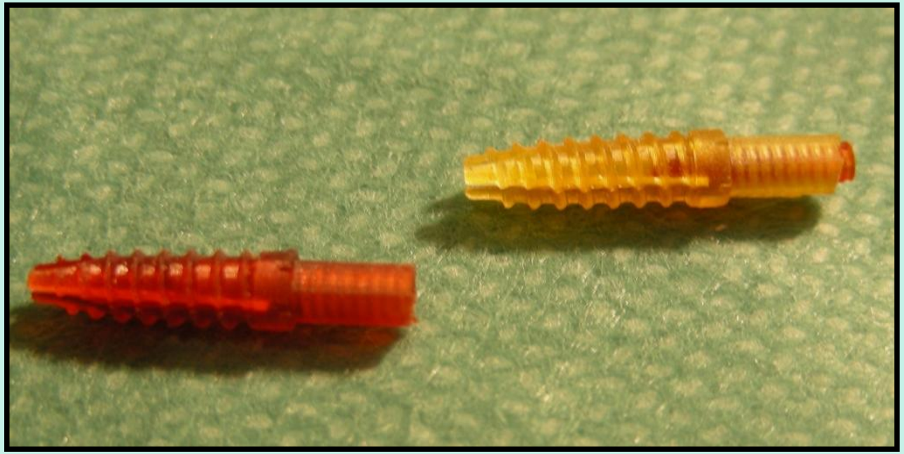


Figure 12.10 Model developed in final specification before prototype is produced.

12. PRODUCTION OF PROTOTYPE

Plastic prototypes were produced with the aim to produce the model. The plastic models were taken from specially developed prototyping machines thus we had very successful prototypes of the developed dental implant design.

These prototypes were then casted in dental metal production oven but the casting was not succesfull when the product was carried in casting to titanium.



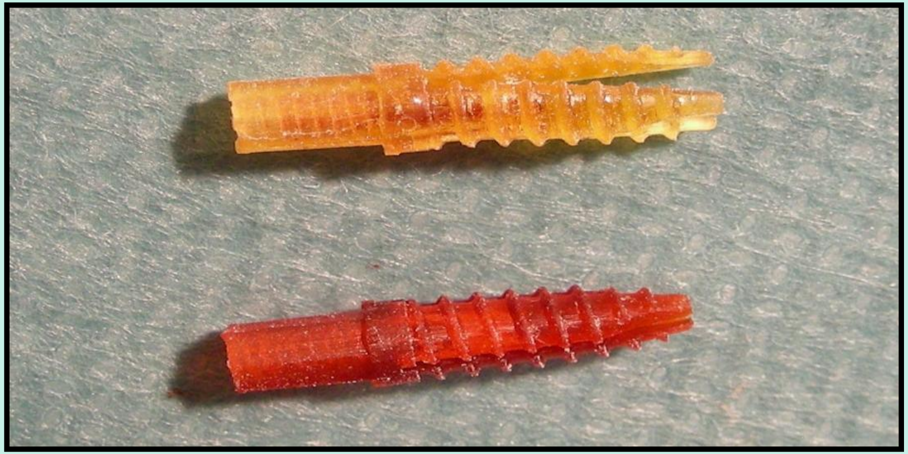


Figure 12.11 Model developed in final specification at software is transferred to prototype produced.

Figure 12.12 Model developed in final specification at software is transferred to prototype is tested to function (opening) in apical arms.

The design developed for this research has surface and structure which is really complicated to produce replicas by casting. Then we have decided to step further to pass to the milling machines to produce our developed implant design. Industrial zones in Istanbul was visited many times to find production facilities for medical sensitive products such as implants. During our visits to industrial zones, we have realized that not all types of milling devices are capable to produce products such as implant which need high precisement. We have communicated with the distributors of the international companies selling CNC-milling devices.

Then we were able to find an orthopedic implant production company who accepted to help the research project. The technical drawings of the developed implant design was prepared to fulfill the ... nts

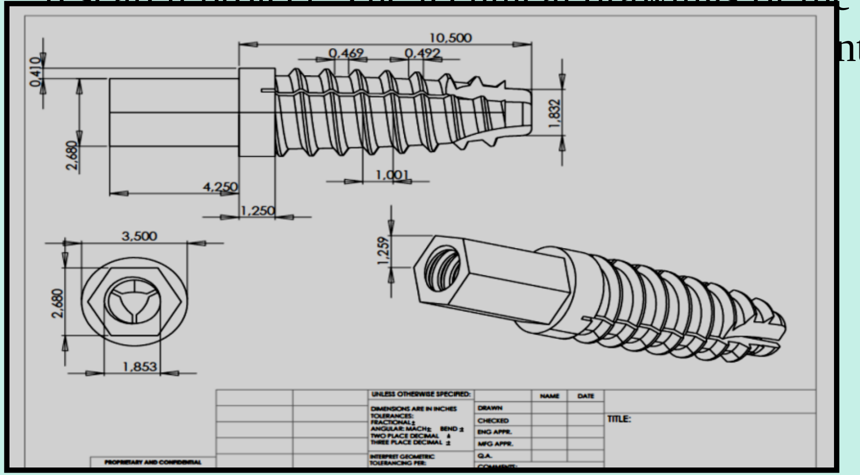


Figure 12.13 Technical drawing of the model developed in final specification for CNC milling.

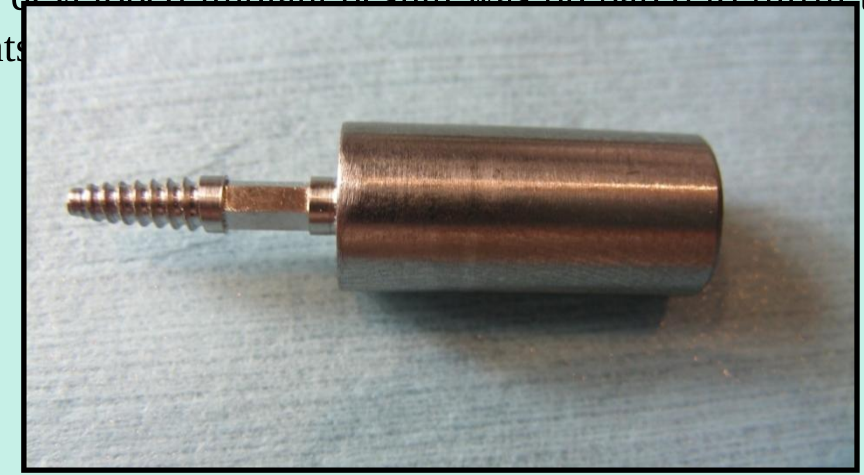


Figure 12.14 Processing of titatium bar at CNC milling machine.

12. PRODUCTION OF PROTOTYPE

The developed implant design samples were produced from Grade 4 Titanium. The titanium bars were treated in milling machines to adapt to the design, and then cleaned for testing. For this research also control implants were produced, totaly in exact shape but without the apical arms which are supposed to be opened inside the bone after insertion.

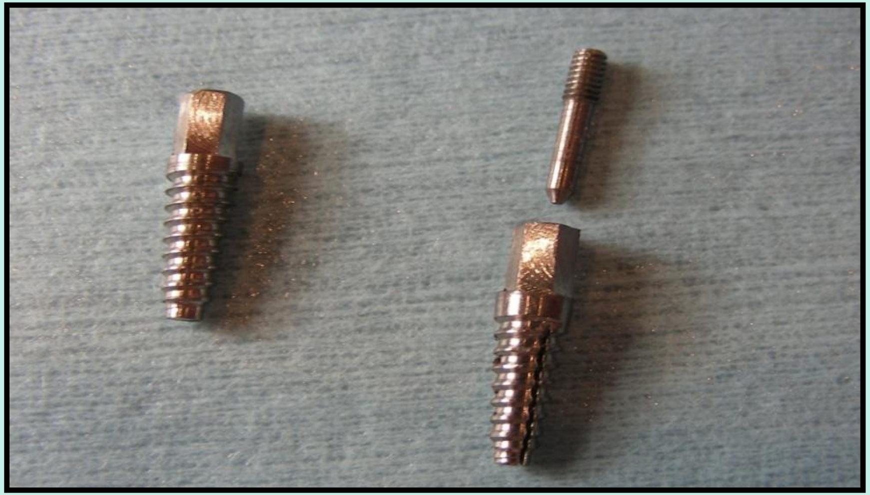


Figure 12.15 Manufactured control implant(left) and developed implant design(right).

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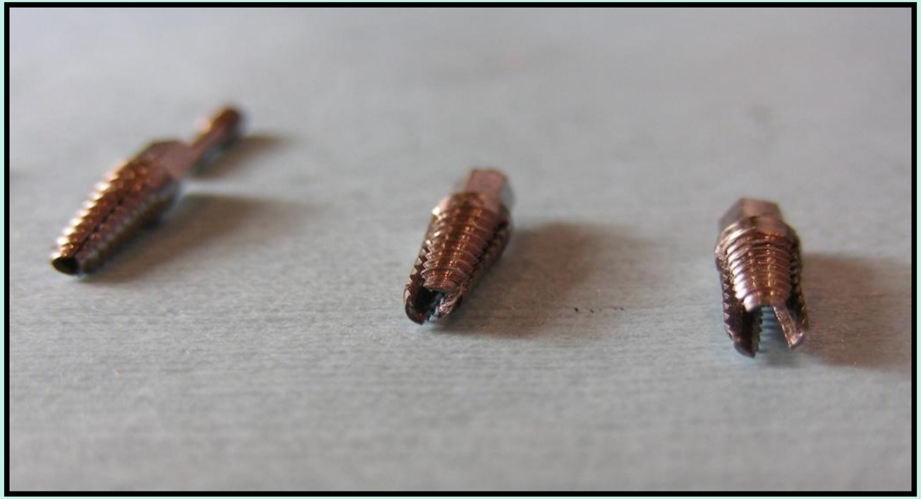


Figure 12.16 Manufactured implant design, apical arms of the implant are opened.

Developed implant design was fabricated from Grade 4 type titanium. It has been suggested that implants should also be evaluated for possible rotational movements. Recently, it was, e.g., proposed to apply a reverse-torque test, with forces not exceeding 10Ncm, to every single implant at abutment connection to discover mobile implants [48]. With this procedure, an incidence of 4.7% of early failures was reported. In the report by Sullivan [48], an increase of the reverse-torque test to 20 Ncm was shown to reduce the number of late failures.

In the research of this procedure, in our study three different media is selected as similar structural properties. Im e spinal bone and polymer block.

Figure 13.1 Bovine iliac and spinal bone pieces cut into segments for bone testing.

15. PREMIER STABILITY TESTS

in all samples and in three different media was applied with digital torque control in sequences of 5

Table 13.1 Bovine spinal bone test sample 1 findings.

Bovine Spinal Bone Sample 1	Implant Control	Implant Designed	Implant Control	Implant Designed
Position	1	2	3	4
5 Ncm	+	+	+	+
10 Ncm	+	+	+	+
15 Ncm	+	+	+	+
20 Ncm	+	+	+	+
25 Ncm	+	+	+	+
30 Ncm	+	+	+	+
35 Ncm	+	+	+	+
40 Ncm	+	+	+	+
45 Ncm	+	-	+	-
50 Ncm	+	-	+	-
Removal Torque Ncm	50	40	50	40
Insertion Torque Ncm	50	30	50	30
Resistance gained Ncm	0	+10	0	+10
Resistance Gained %	0	+%33	0	+%33

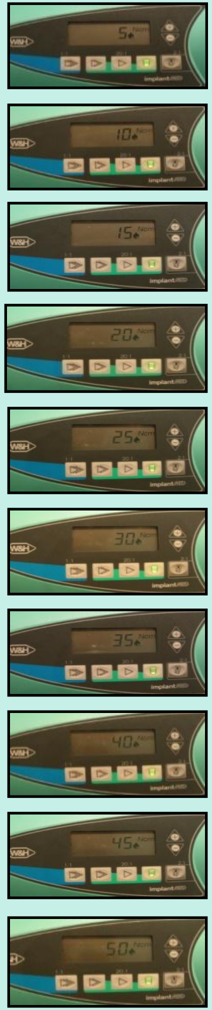


Figure 13.2

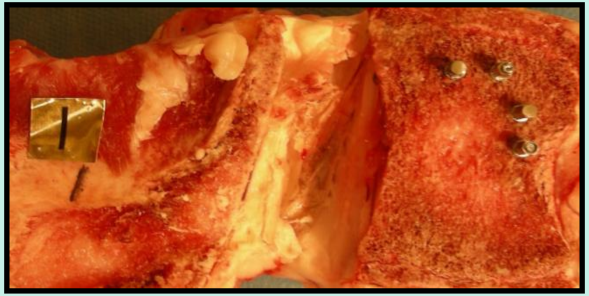


Figure 13.3

Table 13.2 Bovine Spinal Bone test sample 2 findings

Bovine Spinal Bone Sample 2	Control Implant	Designed Implant	Control Implant	Designed Implant
Position	2	1	4	3
5 Ncm	+	+	+	+
10 Ncm	+	+	+	+
15 Ncm	+	+	+	+
20 Ncm	+	+	+	+
25 Ncm	+	+	+	+
30 Ncm	+	+	+	+
35 Ncm	+	+	+	+
40 Ncm	+	-	+	+
45 Ncm	+	-	+	-
50 Ncm	-	-	-	-
Removal Torque Ncm	45	35	45	40
Insertion Torque Ncm	45	25	45	30
Resistance gained Ncm	0	+10	0	+10
Resistance Gained %	0	+%40	0	+%33

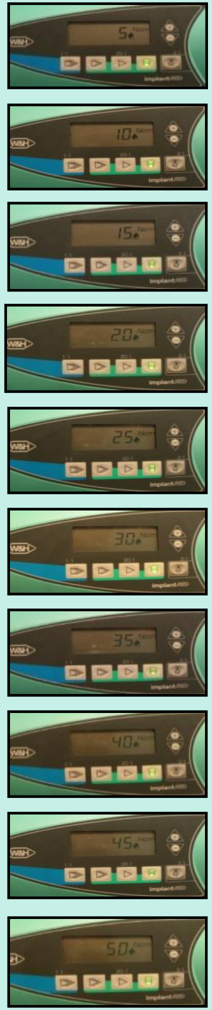


Figure 13.4

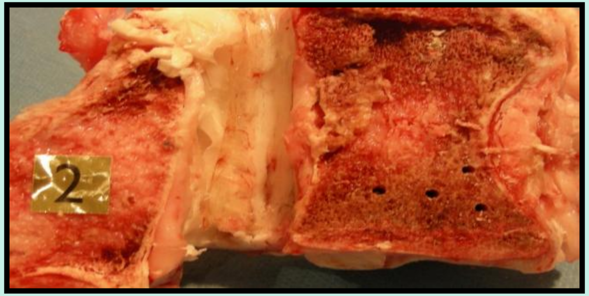


Figure 13.5

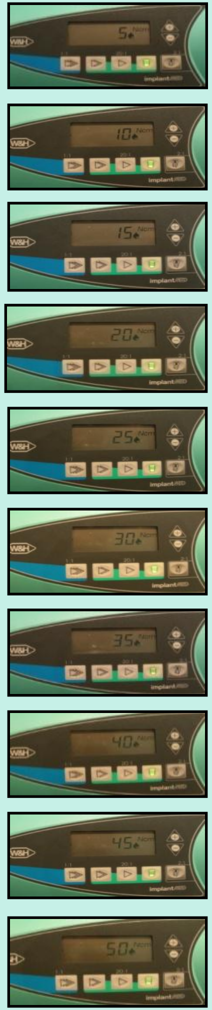


Table 13.3 Bovine Spinal Bone test sample 3 findings

Bovine Spinal Bone Sample 3	Control Implant	Designed Implant	Control Implant	Designed Implant
Position				
5 Ncm	+	+	+	+
10 Ncm	+	+	+	+
15 Ncm	+	+	+	+
20 Ncm	+	+	+	+
25 Ncm	+	+	+	+
30 Ncm	+	+	+	+
35 Ncm	+	+	+	+
40 Ncm	+	+	+	+
45 Ncm	+	-	+	+
50 Ncm	-	-	-	-
Removal Torque Ncm	45	40	45	45
Insertion Torque Ncm	45	30	45	35
Resistance gained Ncm	0	+10	0	+10

Figure 13.6

Figure 13.7

Table 13.4 Bovine Spinal Bone test sample 4 findings

Bovine Spinal Bone Sample 4	Control Implant	Designed Implant	Control Implant	Designed Implant
Position	3	1	4	2
5 Ncm	+	+	+	+
10 Ncm	+	+	+	+
15 Ncm	+	+	+	+
20 Ncm	+	+	+	+
25 Ncm	+	+	+	+
30 Ncm	+	+	+	+
35 Ncm	+	+	+	+
40 Ncm	+	+	+	+
45 Ncm	+	-	+	-
50 Ncm	-	-	-	-
Removal Torque Ncm	45	40	45	40
Insertion Torque Ncm	40	30	40	25
Resistance gained Ncm	+5	+10	+5	+15
Resistance Gained %	+%12	+%33	+%12	+%60







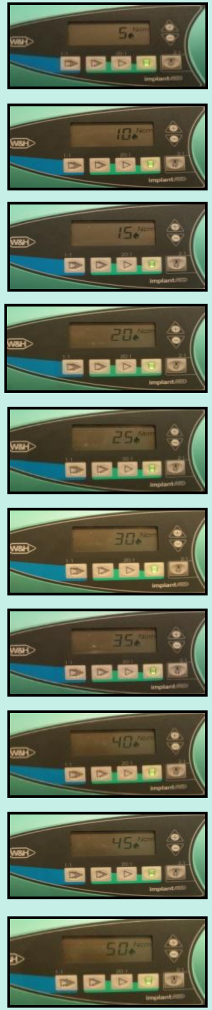



Figure 13.8

Figure 13.9

Table 13.5 Bovine Spinal Bone test sample 5 findings

Bovine Spinal Bone Sample 5	Control Implant	Designed Implant	Control Implant	Designed Implant
Position				
5 Ncm	+	+	+	+
10 Ncm	+	+	+	+
15 Ncm	+	+	+	+
20 Ncm	+	+	+	+
25 Ncm	+	+	+	+
30 Ncm	+	+	+	+
35 Ncm	+	+	+	+
40 Ncm	-	+	+	+
45 Ncm	-	-	+	-
50 Ncm	-	-	-	-
Removal Torque Ncm	35	40	45	40
Insertion Torque Ncm	40	25	35	30
Resistance gained Ncm	-5	+15	+10	+10



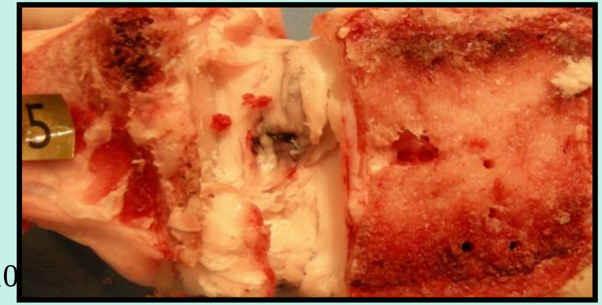


Figure 13.10

Figure 13.11

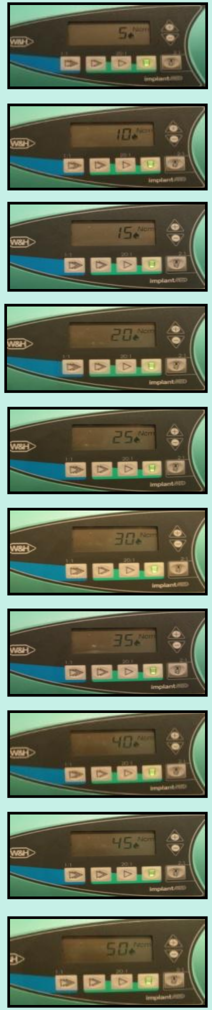


Table 13.6 Bovine Iliac Bone test sample 1 findings

Bovine Iliac Bone Sample 1	Control Implant	Designed Implant	Control Implant	Designed Implant
Position	2	1	3	4
5 Ncm	+	+	+	+
10 Ncm	+	+	+	+
15 Ncm	+	+	+	+
20 Ncm	+	+	+	+
25 Ncm	+	+	-	-
30 Ncm	+	-	-	-
35 Ncm	-	-	-	-
40 Ncm	-	-	-	-
45 Ncm	-	-	-	-
50 Ncm	-	-	-	-
Removal Torque Ncm	30	25	20	20
Insertion Torque Ncm	25	15	25	15
Resistance gained Ncm	+5	+10	-5	+5
Resistance Gained %	+%20	+%66	-%20	+%33

Figure 13.12

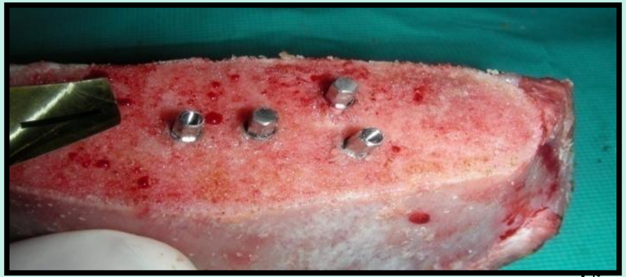
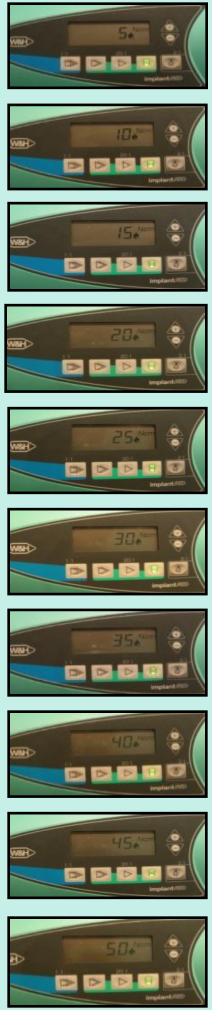


Figure 13.13

Table 13.7 Bovine Iliac Bone test sample 2 findings

Bovine Iliac Bone Sample 2	Control Implant	Designed Implant	Control Implant	Designed Implant
Position	1	2	4	3
5 Ncm	+	+	+	+
10 Ncm	+	+	+	-
15 Ncm	+	+	-	-
20 Ncm	+	-	-	-
25 Ncm	-	-	-	-
30 Ncm	-	-	-	-
35 Ncm	-	-	-	-
40 Ncm	-	-	-	-
45 Ncm	-	-	-	-
50 Ncm	-	-	-	-
Removal Torque Ncm	20	15	10	5
Insertion Torque Ncm	20	10	15	5
Resistance gained Ncm	0	+5	-5	0



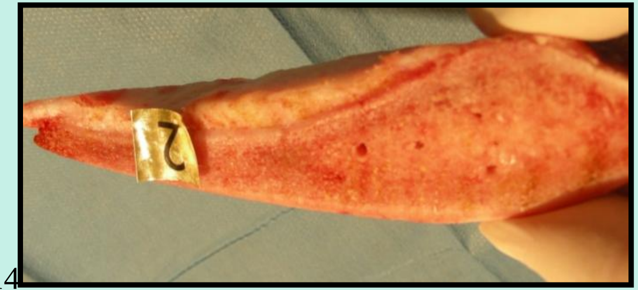


Figure 13.14

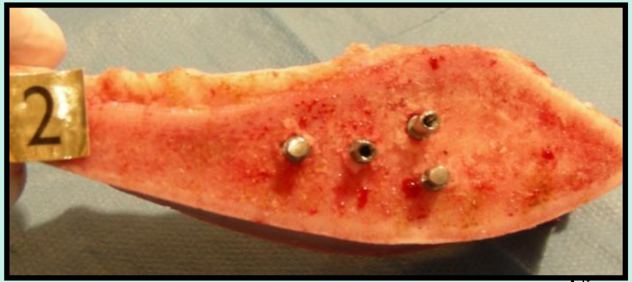


Figure 13.15

Table 13.8 Bovine Iliac Bone test sample 3 findings

Bovine Iliac Bone Sample 3	Control Implant	Designed Implant	Control Implant	Designed Implant
Position	2	1	4	3
5 Ncm	+	+	+	+
10 Ncm	+	+	+	+
15 Ncm	+	+	+	+
20 Ncm	+	+	-	-
25 Ncm	+	-	-	-
30 Ncm	-	-	-	-
35 Ncm	-	-	-	-
40 Ncm	-	-	-	-
45 Ncm	-	-	-	-
50 Ncm	-	-	-	-
Removal Torque Ncm	25	20	15	15
Insertion Torque Ncm	25	15	15	10
Resistance gained Ncm	0	+5	0	+5

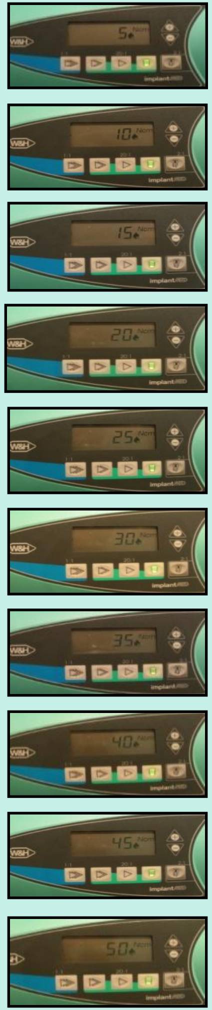


Figure 13.16

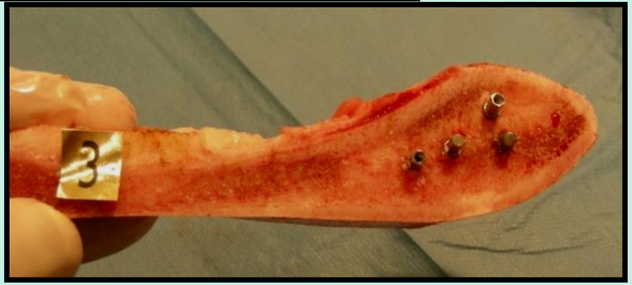
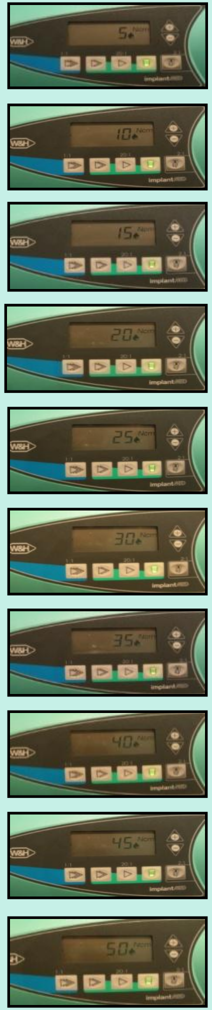


Figure 13.17

Table 13.9 Bovine Iliac Bone test sample 4 findings

Bovine Iliac Bone Sample 4	Control Implant	Designed Implant	Control Implant	Designed Implant
Position	1	2	3	4
5 Ncm	+	+	+	+
10 Ncm	+	+	+	+
15 Ncm	+	+	+	+
20 Ncm	+	+	+	+
25 Ncm	+	+	+	+
30 Ncm	+	+	+	+
35 Ncm	+	-	+	-
40 Ncm	-	-	-	-
45 Ncm	-	-	-	-
50 Ncm	-	-	-	-
Removal Torque Ncm	35	30	35	30
Insertion Torque Ncm	35	20	30	20
Resistance gained Ncm	0	+10	+5	+10
Resistance Gained %	0	+%50	+%16	+%50



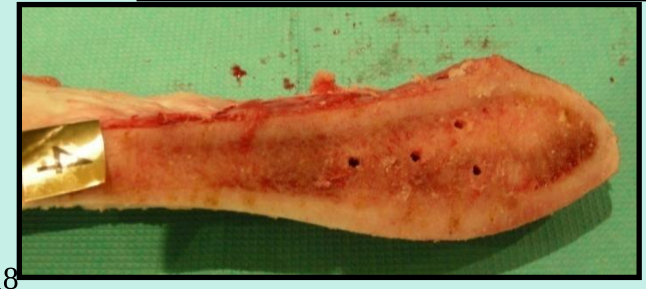


Figure 13.18

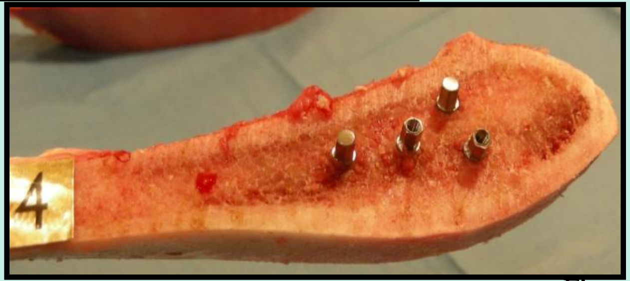
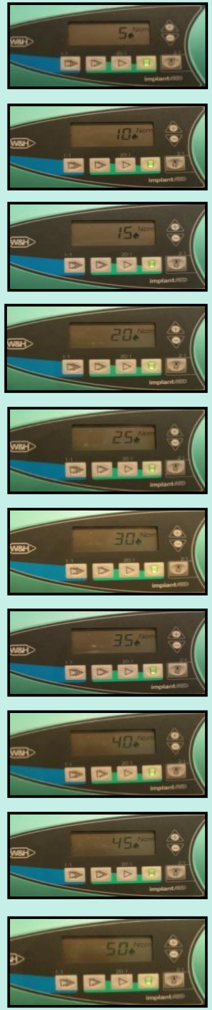


Figure 13.19

Table 13.10 Bovine Iliac Bone test sample 5 findings

Bovine Iliac Bone Sample 5	Control Implant	Designed Implant	Control Implant	Designed Implant
Position	1	3	2	4
5 Ncm	+	+	+	+
10 Ncm	+	+	+	+
15 Ncm	+	+	+	+
20 Ncm	+	+	+	+
25 Ncm	+	-	+	+
30 Ncm	+	-	+	+
35 Ncm	-	-	+	-
40 Ncm	-	-	-	-
45 Ncm	-	-	-	-
50 Ncm	-	-	-	-
Removal Torque Ncm	30	20	35	30
Insertion Torque Ncm	35	20	30	20
Resistance gained Ncm	-5	0	5	+10
Resistance Gained %	-%14	0	%14	+%50



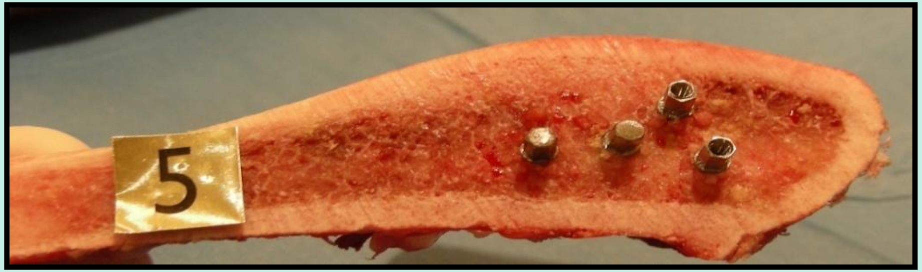


Figure 13.20










Table 13.11 Polymer block test sample 1 findings

Polymer Block Sample 1	Control Implant	Designed Implant
Position	1	2
5 Ncm	+	+
10 Ncm	+	+
15 Ncm	+	+
20 Ncm	-	+
25 Ncm	-	-
30 Ncm	-	-
35 Ncm	-	-
40 Ncm	-	-
45 Ncm	-	-
50 Ncm	-	-
Removal Torque Ncm	15	25
Insertion Torque Ncm	20	15
Resistance gained Ncm	-5	+10
Resistance Gained %	-%25	+%66

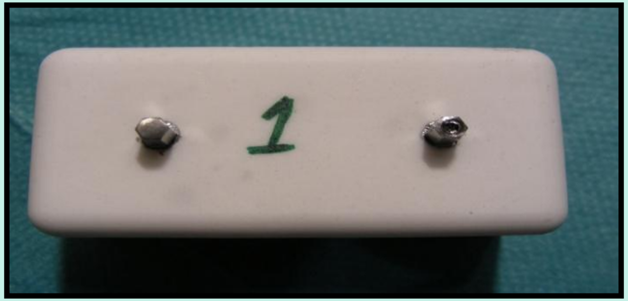


Figure 13.22

Table 13.12 Polymer block test sample 2 findings

Polymer Block Sample 2	Control Implant	Designed Implant
Position	1	2
5 Ncm	+	+
10 Ncm	+	+
15 Ncm	-	+
20 Ncm	-	+
25 Ncm	-	-
30 Ncm	-	-
35 Ncm	-	-
40 Ncm	-	-
45 Ncm	-	-
50 Ncm	-	-
Removal Torque Ncm	10	20
Insertion Torque Ncm	15	15
Resistance gained Ncm	-5	+5
Resistance Gained %	-%33	+%33

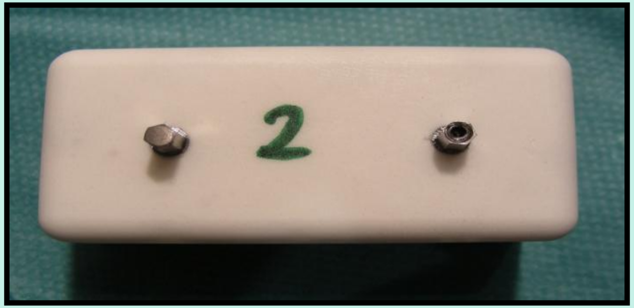


Figure 13.23

Table 13.13 Polymer block test sample 3 findings

Polymer Block Sample 3	Control Implant	Designed Implant
Position	1	2
5 Ncm	+	+
10 Ncm	+	+
15 Ncm	+	+
20 Ncm	-	+
25 Ncm	-	+
30 Ncm	-	+
35 Ncm	-	-
40 Ncm	-	-
45 Ncm	-	-
50 Ncm	-	-
Removal Torque Ncm	15	30
Insertion Torque Ncm	20	20
Resistance gained Ncm	-5	+10
Resistance Gained %	-%25	+%50

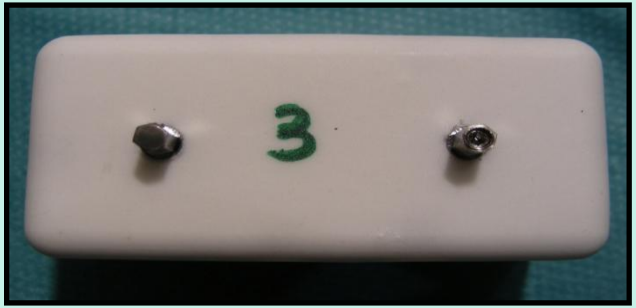
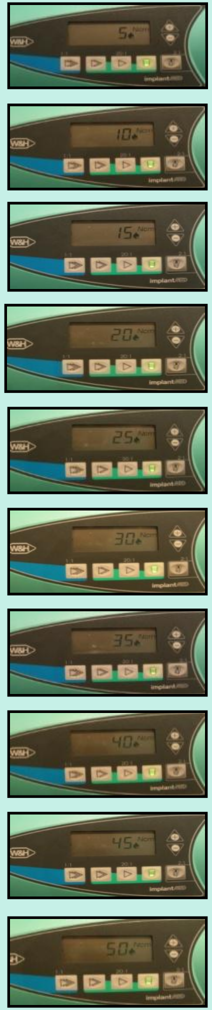


Figure 13.24

Table 13.14 Polymer block test sample 4 findings



Polymer Block Sample 4	Control Implant	Designed Implant
Position	1	2
5 Ncm	+	+
10 Ncm	+	+
15 Ncm	+	+
20 Ncm	+	+
25 Ncm	-	+
30 Ncm	-	+
35 Ncm	-	-
40 Ncm	-	-
45 Ncm	-	-
50 Ncm	-	-
Removal Torque Ncm	20	30
Insertion Torque Ncm	25	20
Resistance gained Ncm	-5	+10
Resistance Gained %	-%20	+%50

Figure 13.25

Table 13.15 Polymer block test sample 5 findings

Polymer Block Sample 5	Control Implant	Designed Implant
Position	1	2
5 Ncm	+	+
10 Ncm	+	+
15 Ncm	+	+
20 Ncm	-	+
25 Ncm	-	-
30 Ncm	-	-
35 Ncm	-	-
40 Ncm	-	-
45 Ncm	-	-
50 Ncm	-	-
Removal Torque Ncm	15	20
Insertion Torque Ncm	20	15
Resistance gained Ncm	-5	+5
Resistance Gained %	-%25	+%33










Figure 13.26

Earlier studies reported different success rates in different regions of the jawbone: 97%, 99%, 89%, and 71% in 673 implants [93] ; 100%, 94%, 92%, and 74% in 137 implants; 94%, 95%, 88%, and 87% in 2359 implants [94], in anterior mandible, posterior mandible, anterior maxilla and posterior maxilla, respectively.

The clinically observed low implant success rates in the posterior maxilla might be due to the fact that the posterior maxilla has the lowest composite apparent density and relatively high hardness, which might indicate low fracture toughness. This could lead to relatively easy fractures of bone during surgical drilling and implant insertion, and resultant low implant stability and success.

The suggested implant design aims to increase the premier stability by the apical arms which extends inside the bone after inserted in the surgically prepared hole. When the apical arms of the develeoped design are opened with the activating screw, the shape of the conical implant transforms into a three rooted molar teeth.

The results of this study indicates promising, in different bone structures and polymer material, designed implant with apical arms has shown relatively average gain of %38.6 in bovine spinal bone samples, %38,2 in bovine iliac bone samples and in polymer block %46.4 gain in retention to removal torques.

Table 14.1 Results of the digital recordings from the developed implant design.

Results of the digital recordings from the developed implant design	Insertion Torque (Ncm)	Removal Torque (Ncm)	Gain (Ncm)	Gain %
Bovine spinal bone sample 1 (a)	30	40	10	33
Bovine spinal bone sample 1 (b)	30	40	10	33
Bovine spinal bone sample 2 (a)	25	35	10	40
Bovine spinal bone sample 2 (b)	30	40	10	33
Bovine spinal bone sample 3 (a)	30	40	10	33
Bovine spinal bone sample 3 (b)	35	45	10	28
Bovine spinal bone sample 4 (a)	30	40	10	33
Bovine spinal bone sample 4 (b)	25	40	15	60
Bovine spinal bone sample 5 (a)	25	40	15	60
Bovine spinal bone sample 5 (b)	30	40	10	33
Bovine iliac bone sample 1 (a)	15	25	10	66
Bovine iliac bone sample 1 (b)	15	20	5	33
Bovine iliac bone sample 2 (a)	10	15	5	50
Bovine iliac bone sample 2 (b)	5	5	0	0
Bovine iliac bone sample 3 (a)	15	20	5	33
Bovine iliac bone sample 3 (b)	10	15	5	50
Bovine iliac bone sample 4 (a)	20	30	10	50
Bovine iliac bone sample 4 (b)	20	30	10	50
Bovine iliac bone sample 5 (a)	20	20	0	0
Bovine iliac bone sample 5 (b)	20	30	10	50
Polymer block sample 1	15	25	10	66
Polymer block sample 2	15	20	5	33
Polymer block sample 3	20	30	10	50
Polymer block sample 4	20	30	10	50
Polymer block sample 5	15	20	5	33

Table 14.2 Results of the digital recordings from the control implant design.

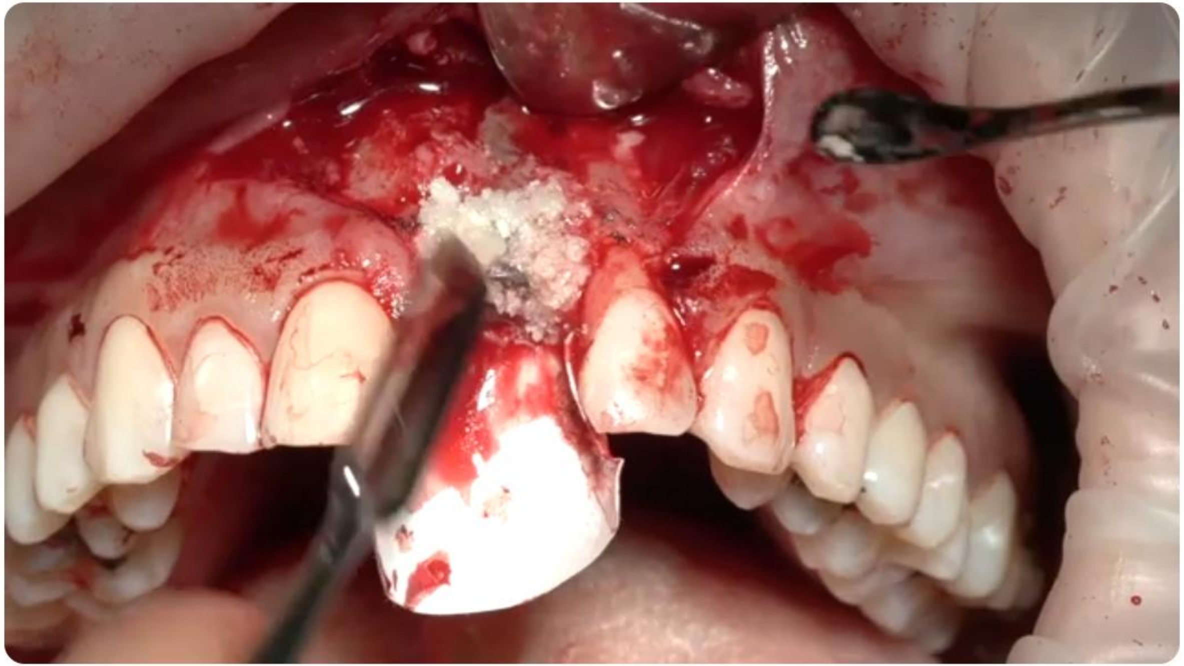
Results of the digital recordings from the control implant design	Insertion Torque (Ncm)	Removal Torque (Ncm)	Gain (Ncm)	Gain %
Bovine spinal bone sample 1 (a)	50	50	0	0
Bovine spinal bone sample 1 (b)	50	50	0	0
Bovine spinal bone sample 2 (a)	45	45	0	0
Bovine spinal bone sample 2 (b)	45	45	0	0
Bovine spinal bone sample 3 (a)	45	45	0	0
Bovine spinal bone sample 3 (b)	45	45	0	0
Bovine spinal bone sample 4 (a)	40	45	5	12
Bovine spinal bone sample 4 (b)	40	45	5	12
Bovine spinal bone sample 5 (a)	40	35	-5	-12
Bovine spinal bone sample 5 (b)	35	45	10	28
Bovine iliac bone sample 1 (a)	25	30	5	20
Bovine iliac bone sample 1 (b)	25	20	-5	-20
Bovine iliac bone sample 2 (a)	20	20	0	0
Bovine iliac bone sample 2 (b)	15	10	-5	-33
Bovine iliac bone sample 3 (a)	25	25	0	0
Bovine iliac bone sample 3 (b)	15	15	0	0
Bovine iliac bone sample 4 (a)	35	35	0	0
Bovine iliac bone sample 4 (b)	30	35	5	16
Bovine iliac bone sample 5 (a)	35	30	-5	-14
Bovine iliac bone sample 5 (b)	30	35	5	14
Polyme block sample 1	20	15	-5	-25
Polyme block sample 2	15	10	-5	-33
Polyme block sample 3	20	15	-5	-25
Polyme block sample 4	25	20	-5	-20
Polyme block sample 5	20	15	-5	-25

Earlier studies reported different success rates in different regions of the jawbone: 97%, 99%, 89%, and 71% in 673 implants [93] ; 100%, 94%, 92%, and 74% in 137 implants; 94%, 95%, 88%, and 87% in 2359 implants [94], in anterior mandible, posterior mandible, anterior maxilla and posterior maxilla, respectively.

Evethough there are many types of implants available in the medical applications, some developments are required regarding the need of improving the success of surgical interventions. The research implemented to use titanium which is well documented to provide all necessary mechanical and bio-compatibility requirements. This research focused to propose a new implant design, not conical or cylindrical designs which are actual designs applied, but a new design which will resemble the tooth anatomy as with roots, thus increase the premier stability and open new indications to implant applications.

The results of this study indicates promising, in different bone structures and polymer material, designed implant with apical arms has shown relatively average gain of %38.6 in bovine spinal bone samples, %38,2 in bovine iliac bone samples and in polymer block %46.4 gain in retention to removal torques; thus positive future directions to make further researches on the material production and also testings of such a new dental implant design including in vivo clinical controlled studies will be benefical for better understanding the behaviour of the developed implant design under different conditions.

IMPLANT SURGERY + Bone Substitutes + Membrane



SURGERY: Implant placement + simultaneous hard- and soft tissue augmentation in the aesthetic zone

SUPPERIOSTAL IMPLANTS

https://youtu.be/hPTRD7T2d9E?si=rvexN2q4XVU0iRdz

RETROSPECTIVE IMPLANT STUDY

Descriptive Statistics

prepared by Drs

Lauverjat & Sozkes

8520 Implants in 2296 Patients

Data from 1994 to 2000

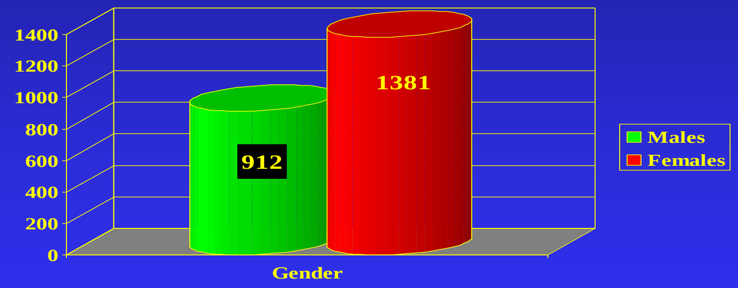
With participations of Drs ;

AREVALO	**Italy**
CANNİZZARO	**Italy**
CARUSİ	**France**
EL ASKARY	**Egypt**
KOROMPLİLAS	**USA**
LAUVERJAT	**France**

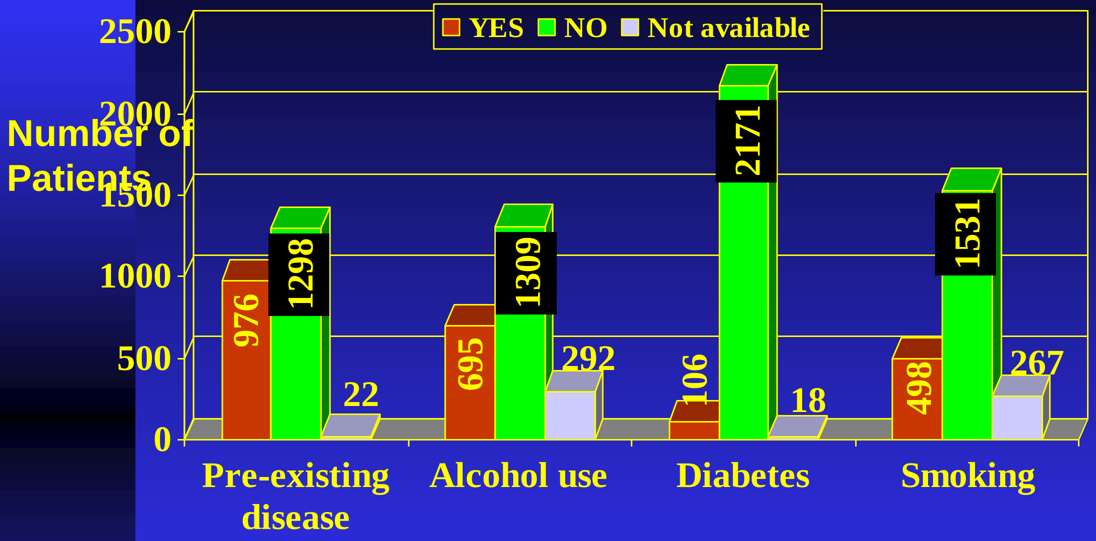
PATIENTS;

- ***Females*** *(60.1 %)* ***1381***
- ***Males*** *(39.7 %)* ***912***

Number of Patients

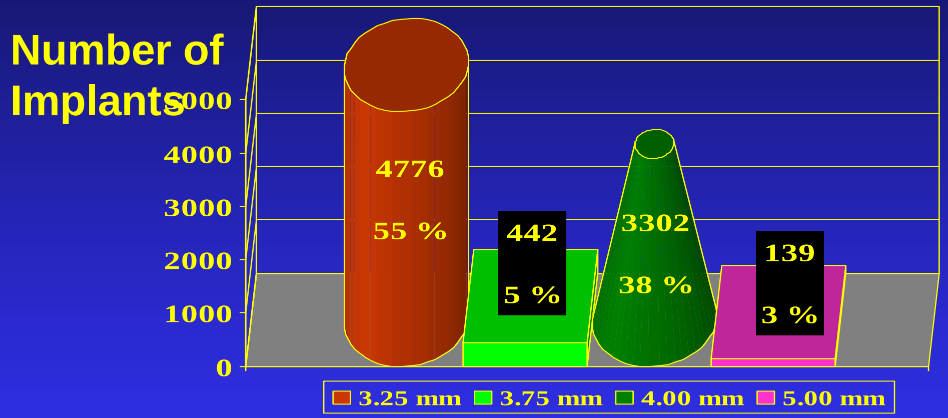


SYSTEMIC CONDITIONS



43%   35%   5 %   25 %

DIAMETER



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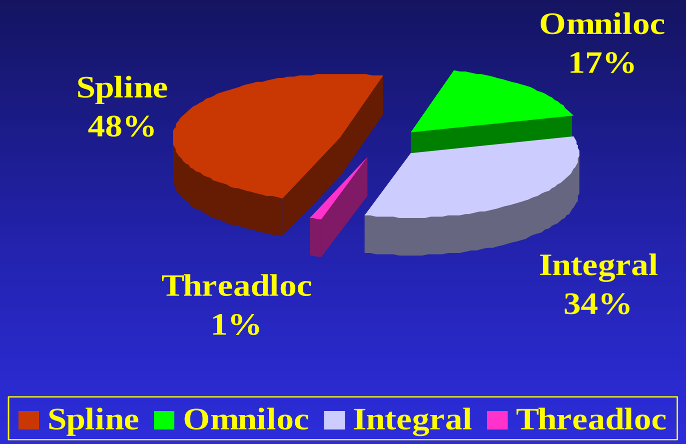
Type of implant



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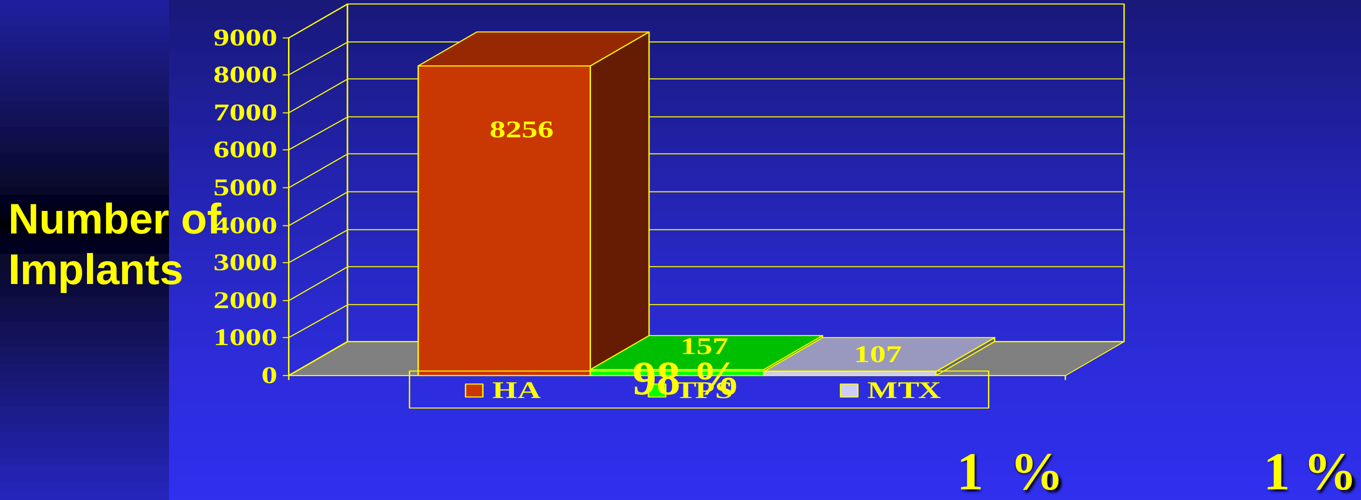
Surface Coating of implants



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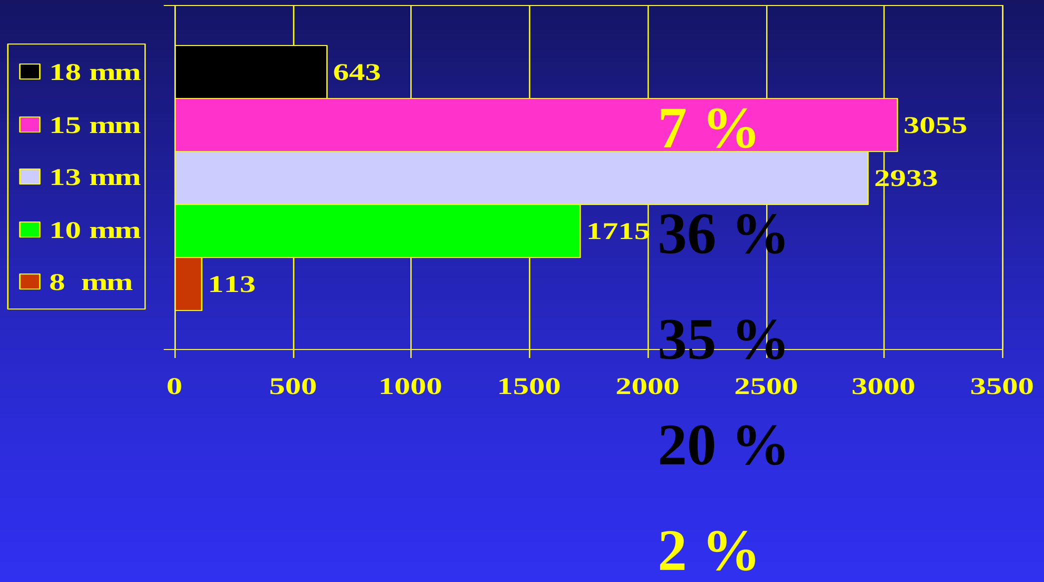
Lenght of implants



Number of Implants

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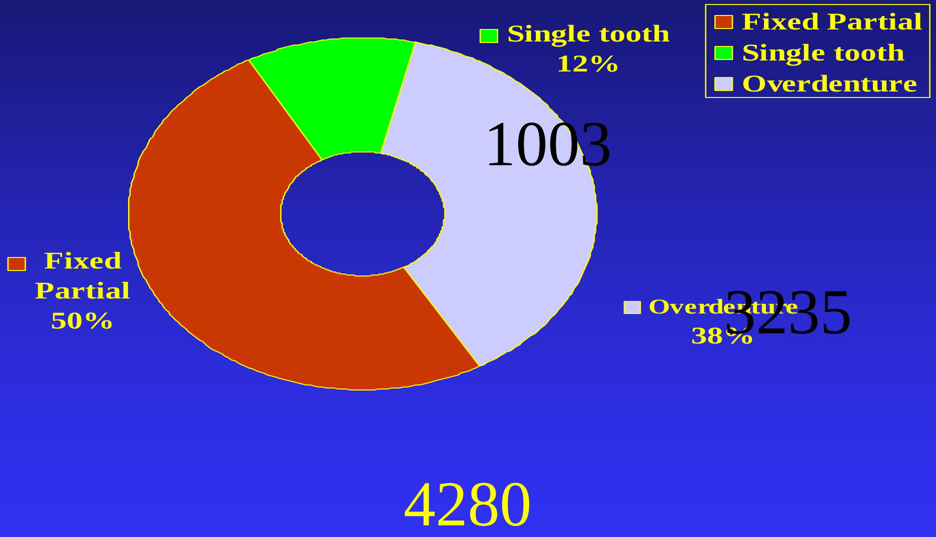
Restoration Type



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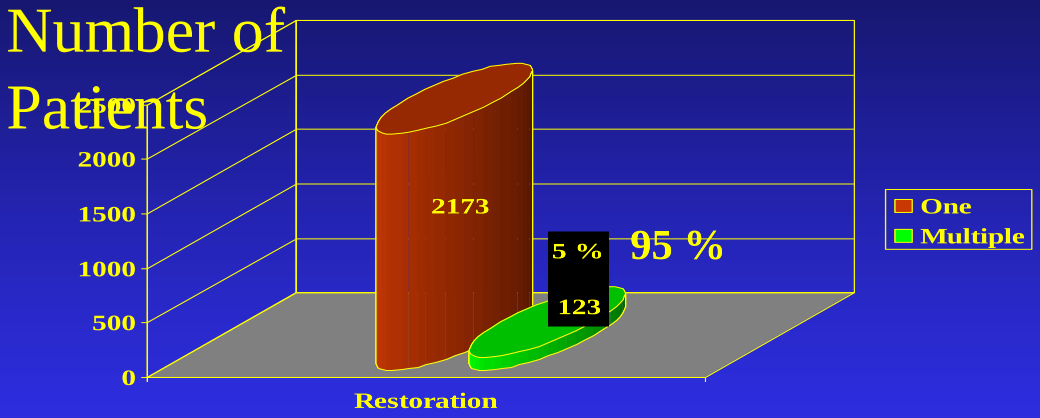
Restoration plan



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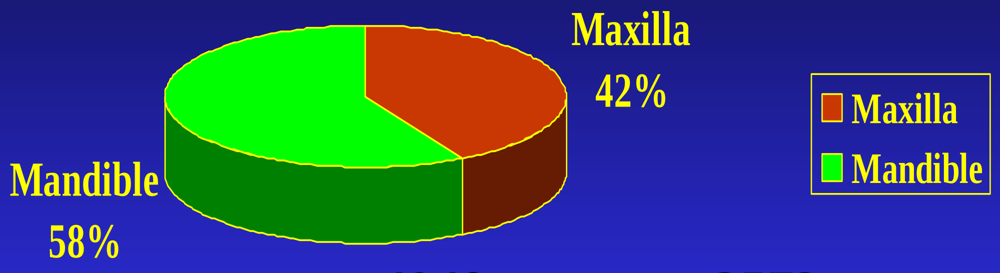
Location of restorations



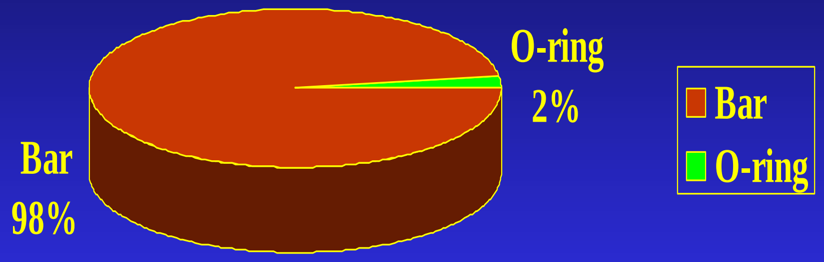
4948 3572

Lauverjat & Sozkes

CEMENTED OR SCREW??

Lauverjat & Sozkes

When overdentures are fabricated the choice of connection is;



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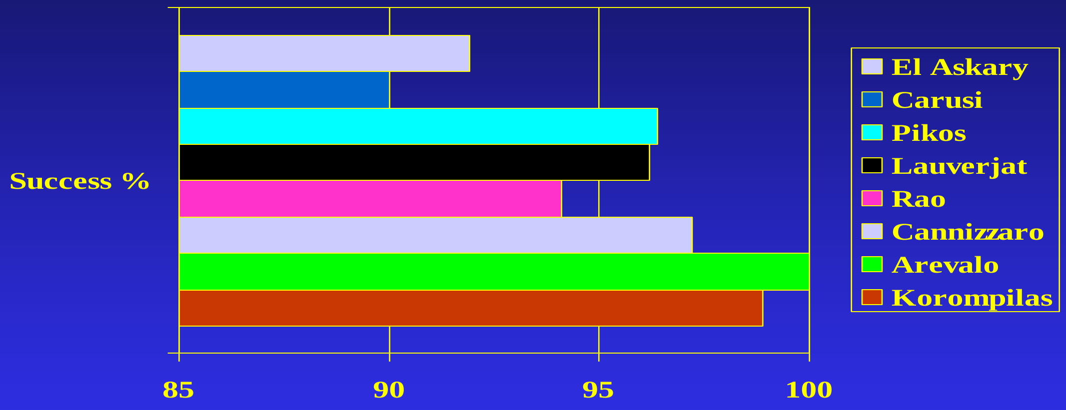
Success

and

Failure

Success by Patient



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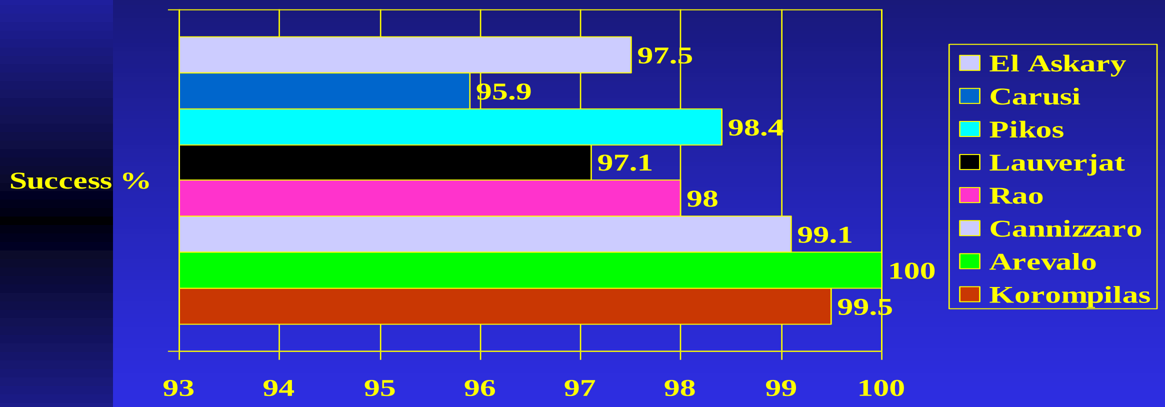
Success by implant



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Outcome by gender

Number of Patients

	MALE	FEMALE	TOTAL
Failure	32	40	72
Success	880	1341	2221
	912	1381	2293

Difference non significative

Chi-square = 0.677, p-value > 0.05

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Outcome by Diabetes

Number of Patients

	Diabetic	Not Diabetic	TOTAL
Failure	6	65	71
Success	100	2106	2206
	106	2171	2277

Difference non significative

Chi-square = 2.379, p-value > 0.05

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Outcome by Systemic Disease

Number of Patients

	Systemic Disease	No Systemic Disease	TOTAL
Failure	29	41	70
Success	947	1257	2204
	976	1298	2274

Difference non significative

Chi-square = 0.066, p-value > 0.05

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Outcome by Alcohol Use

Number of Patients

	Alcohol Use	No Alcohol Use	TOTAL
Failure	24	36	60
Success	671	1273	1944
	695	1309	2004

Difference non significative

Chi-square = 0.773, p-value > 0.05

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Outcome by Smoking

Number of Patients

	Smoker	Non Smoker	TOTAL
Failure	30	33	63
Success	468	1498	1966
	498	1531	2029

Difference significative

Chi-square = 18.69, p-value < 0.001 ***

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Outcome by Number of Restorations

Number of Patients

	One Restoration	Multiple Restoration	TOTAL
Failure	63	9	72
Success	2110	114	2224
	2173	123	2296

Difference significative

Chi-square = 7.48 , p-value < 0.01 ***

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Outcome by Location

Number of Implants

	Maxilla	Mandible	TOTAL
Failure	52	61	113
Success	3520	4887	8407
	3572	4948	8520

Difference non significative

Chi-square = 0.789 , p-value > 0.05

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Implant Survival Over Time

Follow-up from time of restoration		Failed	Survival
< 1 year		71	0.990
1 – 2 years		15	0.988
2 – 3 years		1	0.988
3 – 4 years		1	0.988
4 – 5 years		1	0.987
> 5 years		0	0.987

Lauverjat & Sozkes

Distraction Osteogenesis System

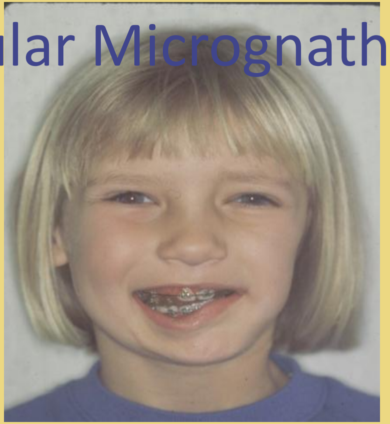
LOGIC™ Mandibular Distraction System SPECTRUM™: Midface Multi-vector Intra-oral Distractor

LOGIC™ Distraction

Mandibular Distraction Applications

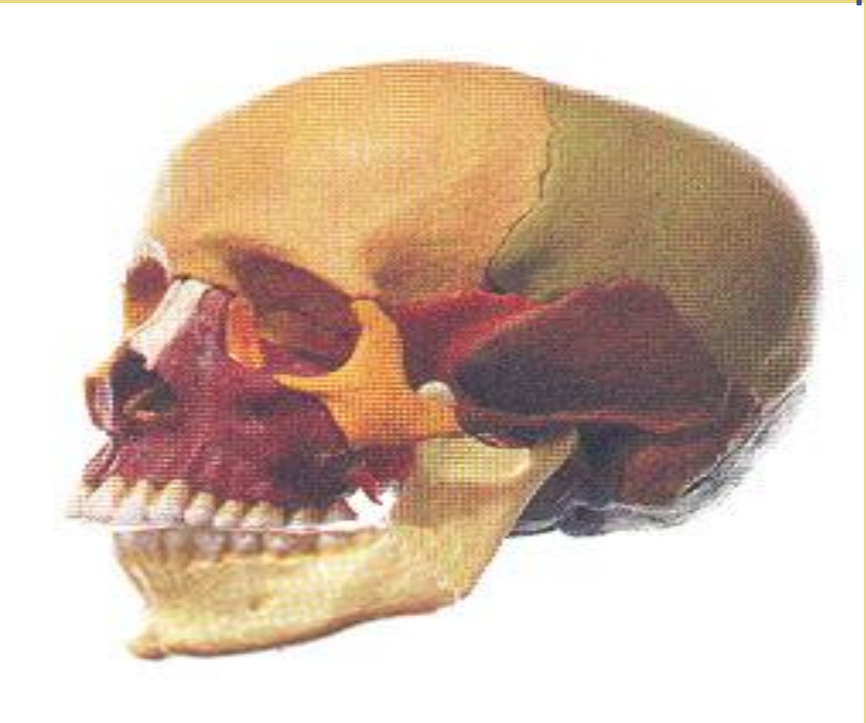
Hemifacial Microsomia

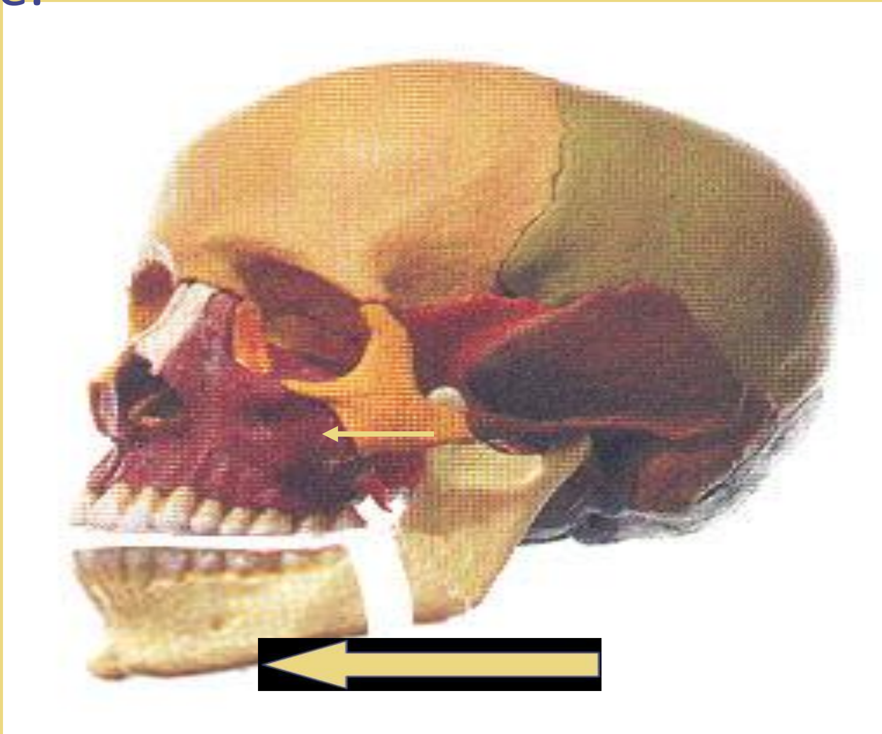
Mandibular Micrognathia



LOGIC™ Mandibular Distractor Logic Theory:

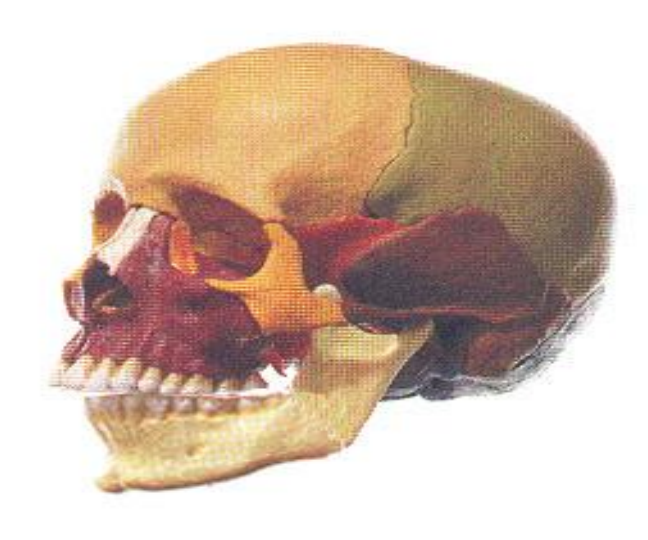
If the mandible is extended only horizontally, it may result in an anterior open bite.

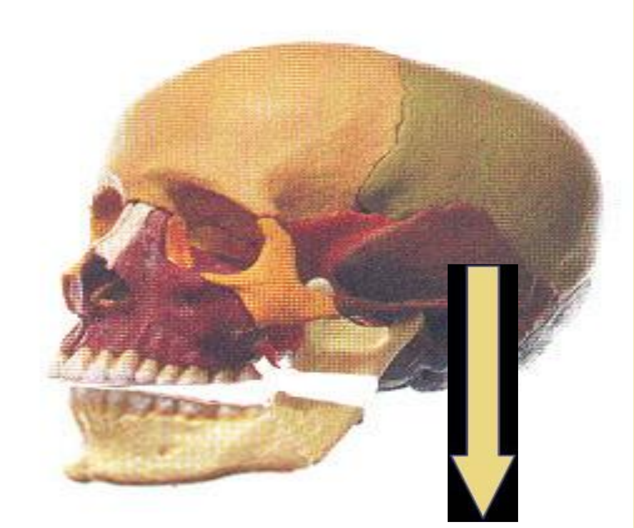


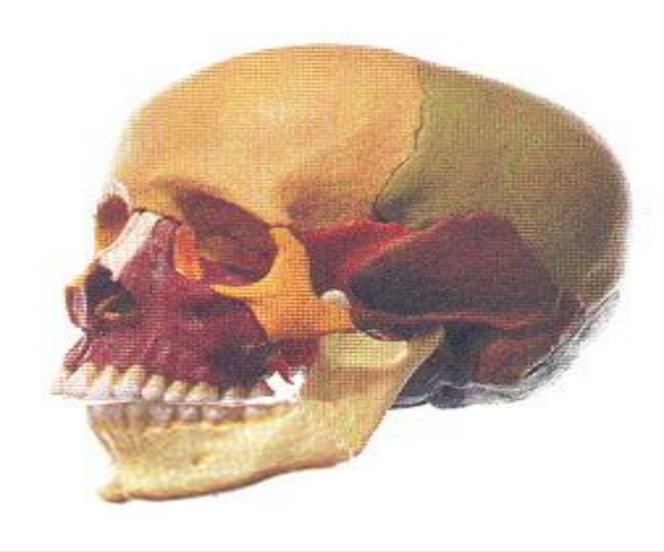
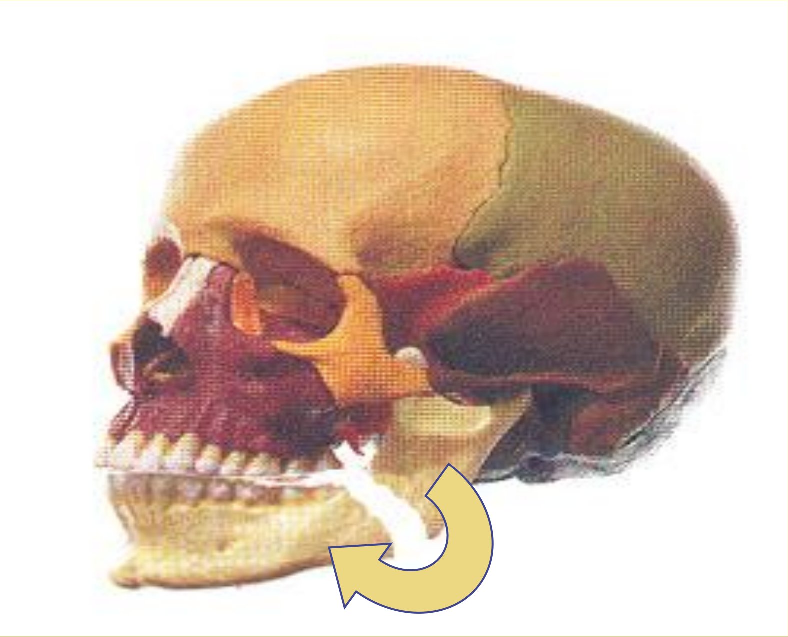


LOGIC™ Mandibular Distractor Logic Theory:

The LOGIC distractor promotes bone growth in both horizontal and vertical vectors, minimizing posterior and anterior open bite.





LOGIC™ Mandibular Distractor Principles:

Mandibular growth follows a logarithmic curve.

LOGIC™ Mandibular Distractor Advantages:

Intraoral device; no external pins, so no scarring.

Low profile, small; does not restrict patient movement—important as most cases are pediatric

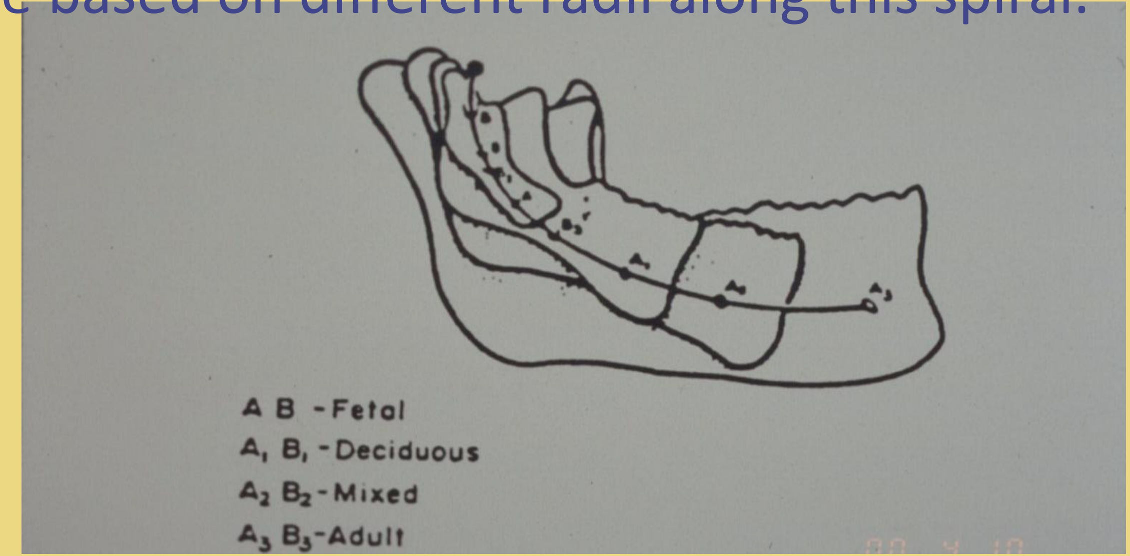
A distractor with both horizontal and vertical vectors; the new bone mimics the mandible's natural growth curve, minimizing open bites.

The activation key is flexible, providing excellent stability and convenience during activation.

During consolidation, it stays under the periosteum, preventing soft tissue irritation.

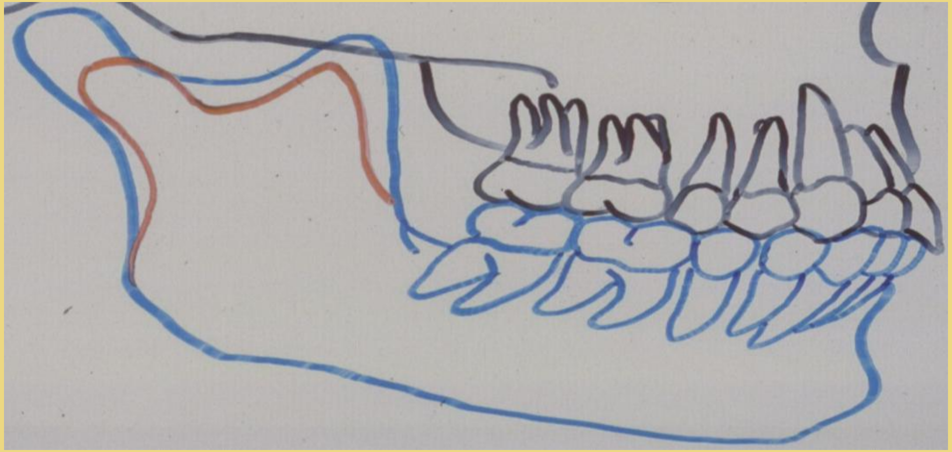
LOGIC™ Mandibular Distractor Logic Theory:

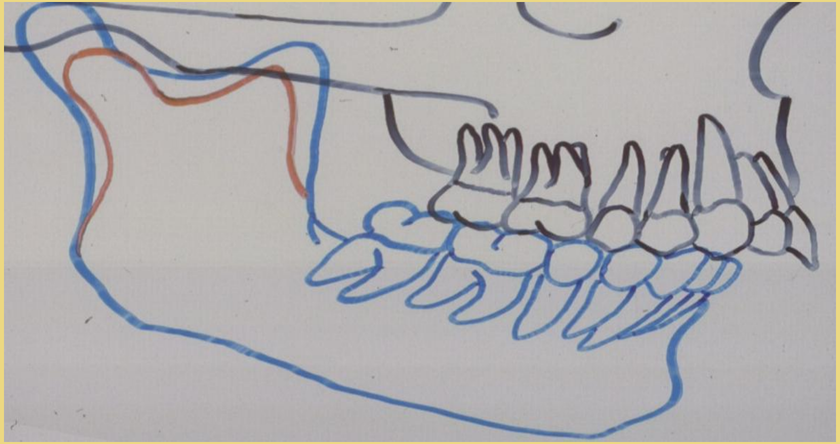
Hypothesis: Mandibular growth is a logarithmic spiral, so distractor angles are based on different radii along this spiral.



LOGIC™ Mandibular Distractor:

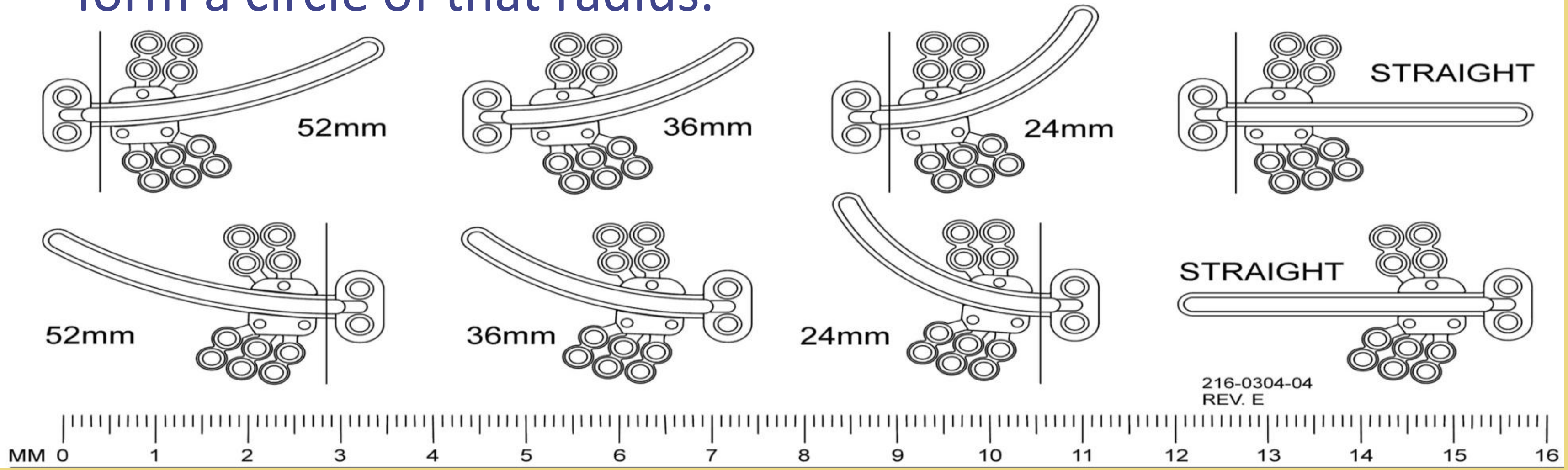
Mandibular Distraction Target: Move the mandible forward until proper occlusion is achieved.





LOGIC™ Mandibular Distractor System Components:

Distractors are named based on the curvature they follow, e.g., a distractor arm with a 52mm radius when fully opened would form a circle of that radius.

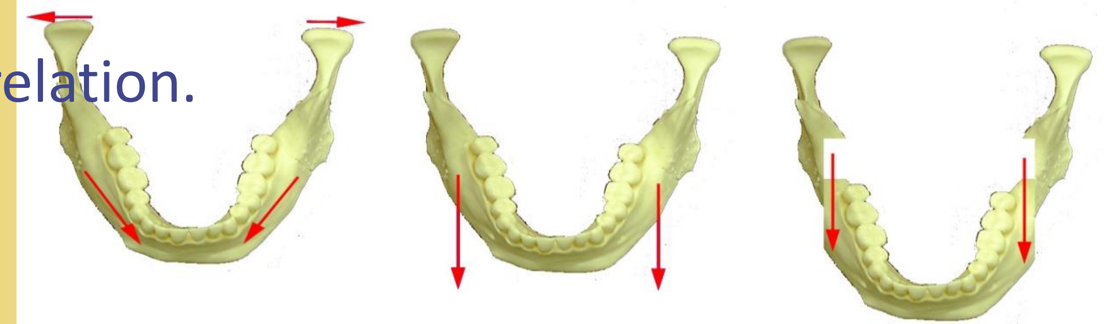


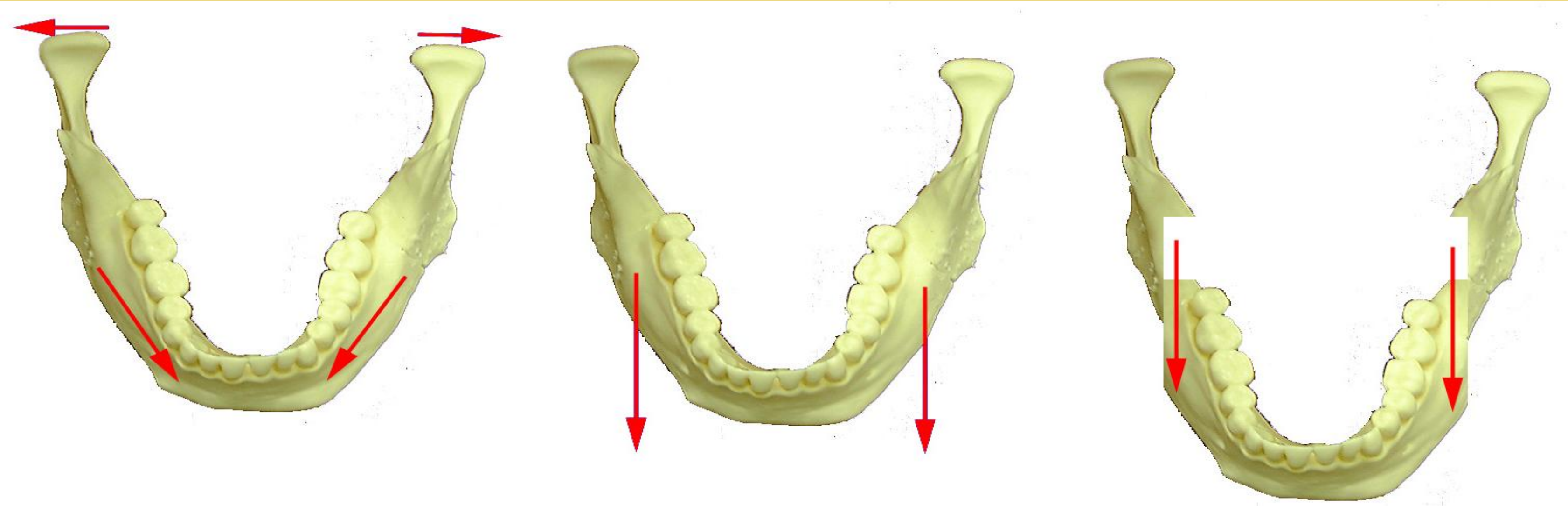
System components:

Activation keys (75, 65, 55, 45, 35mm). Spacers help keep distractors parallel, maintaining condyle/fossa relation as the mandible advances. Spacers also prevent lateral force on the proximal segments, maintaining condyle/fossa relation.

Spacers help keep distractors parallel, maintaining condyle/fossa relation as the mandible advances.,

Spacers also prevent lateral force on the proximal segments, maintaining condyle/fossa relation.





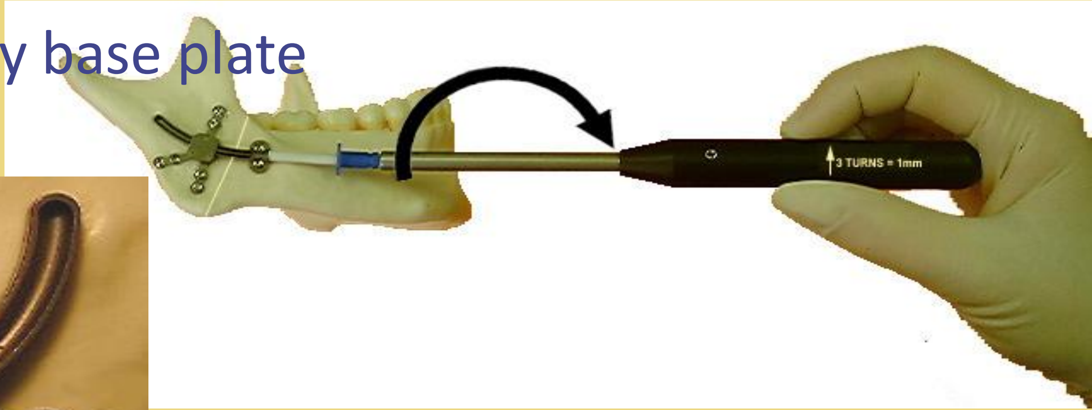
Spacers help keep distractors parallel, maintaining condyle/fossa relation as the mandible advances. Spacers also prevent lateral force on the proximal segments, maintaining condyle/fossa relation.

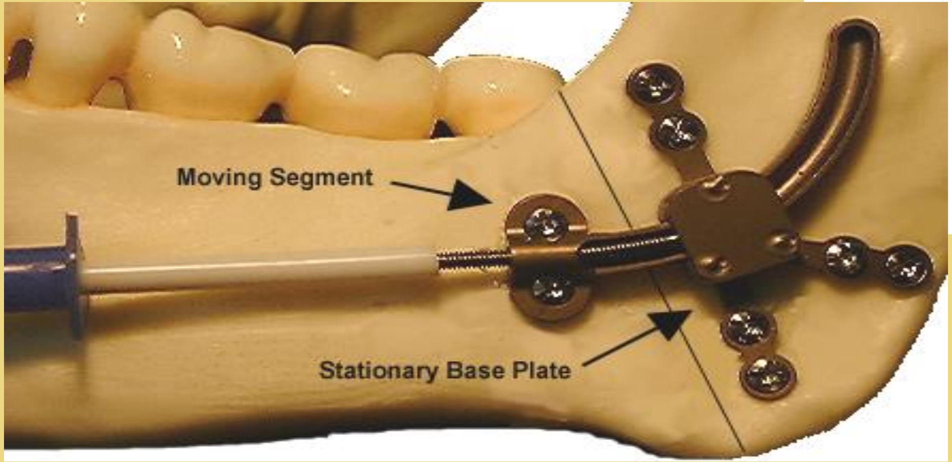
LOGIC™ Mandibular Distractor

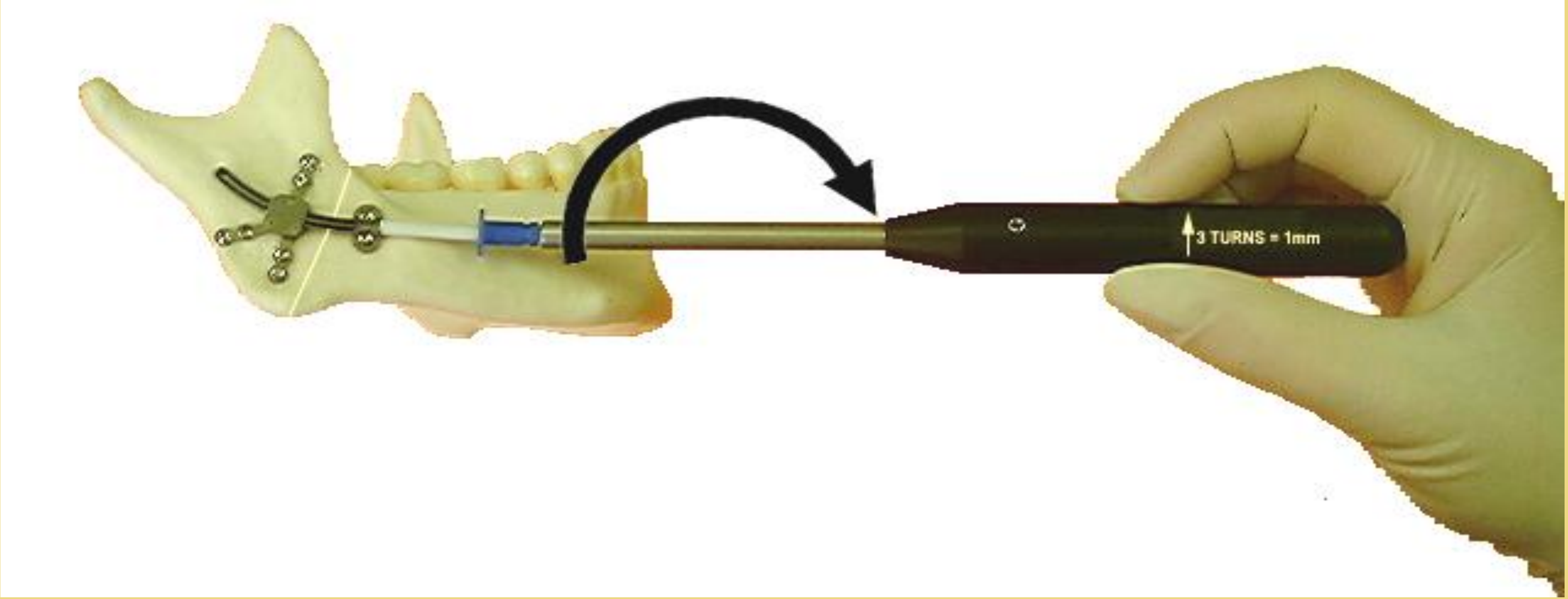
Distractor Operation:

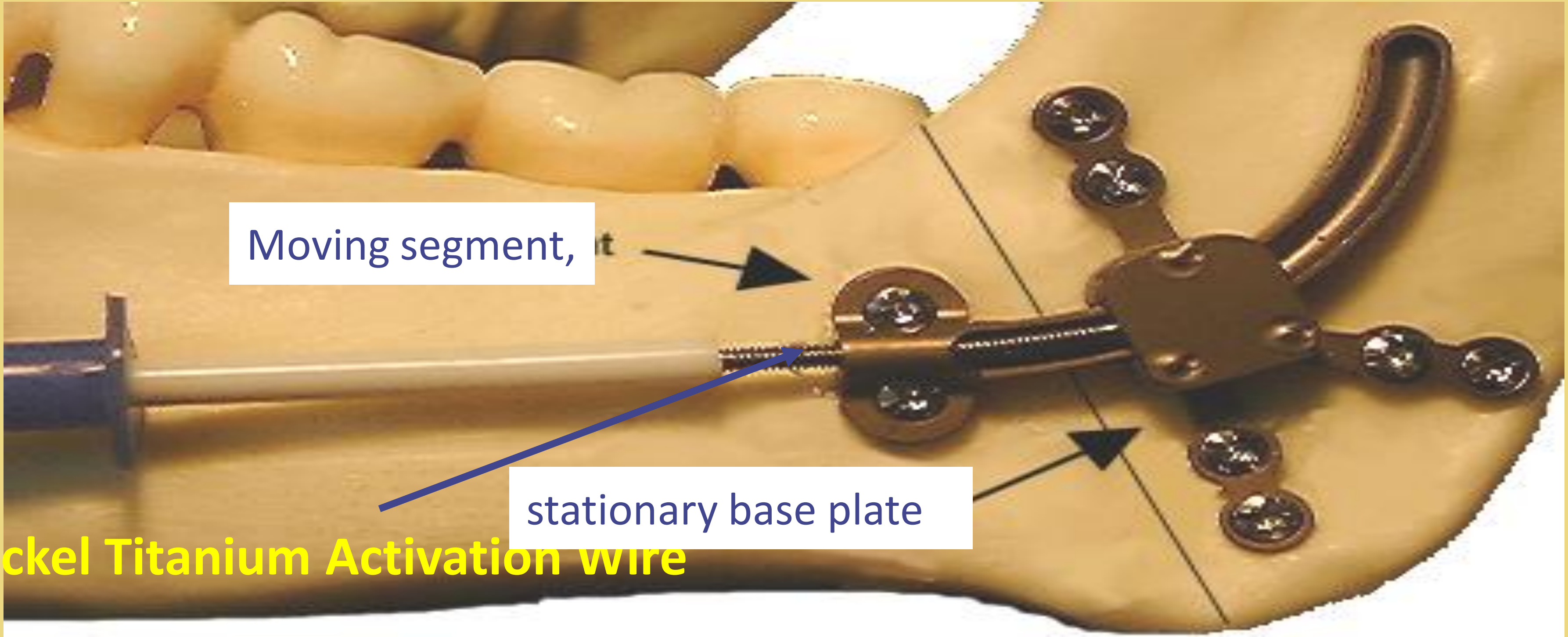
3 turns = 1mm distraction

Moving segment, stationary base plate






3 TURNS = 1mm


Moving segment,
stationary base plate
Nickel Titanium Activation Wire

3 turns = 1mm

Placement planning and selection of curvature:

Options adapting to mandibular growth are straight or three-curved

The curvature is chosen based on desired amount and direction of movement, using a lateral cephalometric radiograph

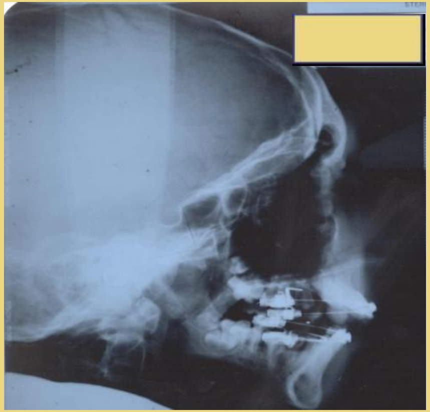
Placement planning and curvature selection:

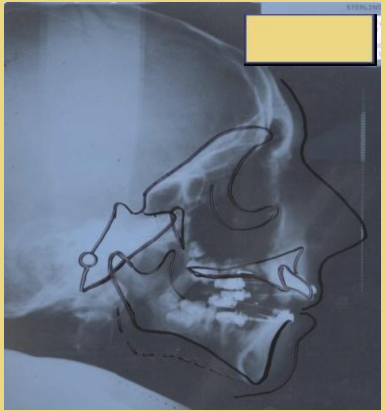
Templates are produced for the surgeon to use lateral and panoramic X-rays to select appropriate curvature and plan necessary distraction. Includes two logarithmic spirals.

Moss Spiral is used for most cases; Golden Spiral is indicated for brachycephalic patients, whose jawbones are more square.

Using the template

- All hard and soft tissue formations are traced on a lateral skull film

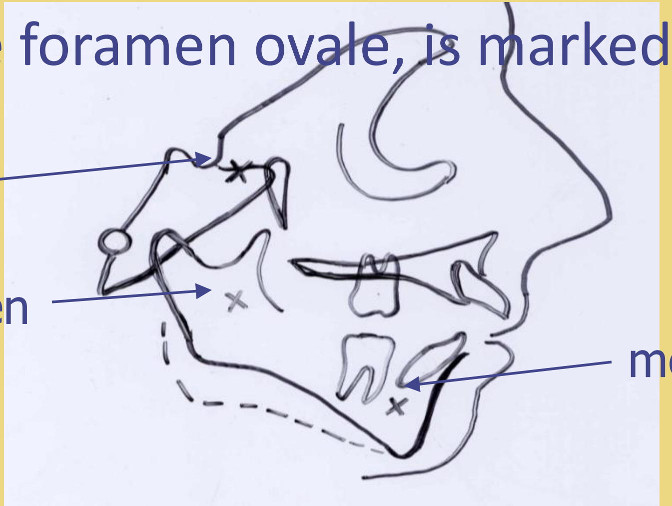




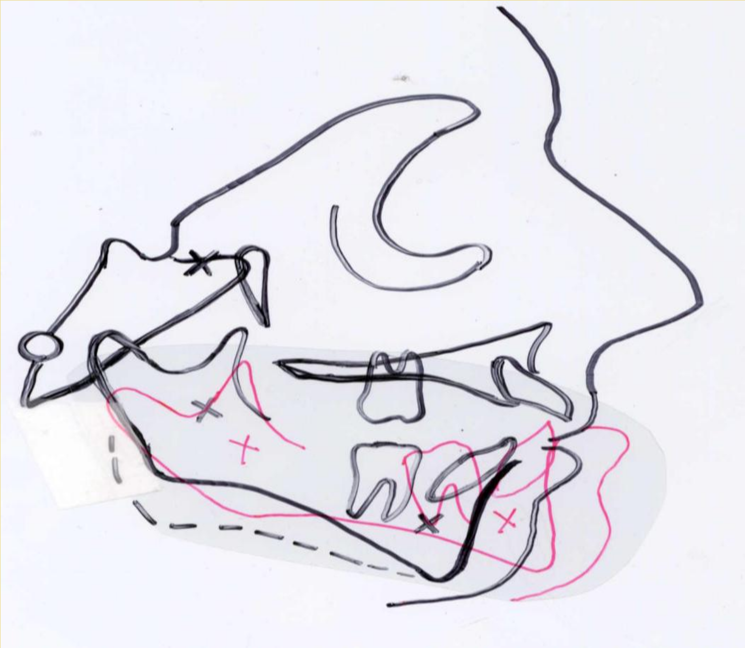
- Tooth positions are then plotted on this projection.

Mental foramen, inferior alveolar foramen, and pterygoid raphe are marked.

After locating the pterygoid raphe, the third critical formation, the foramen ovale, is marked.

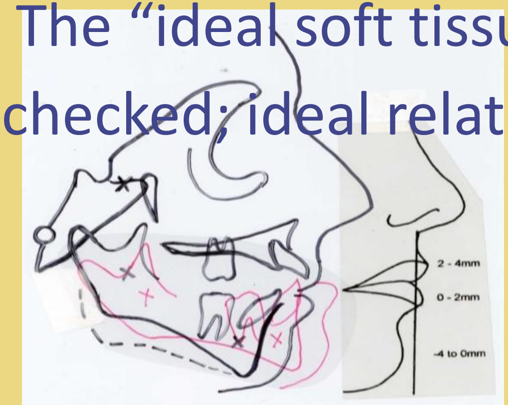


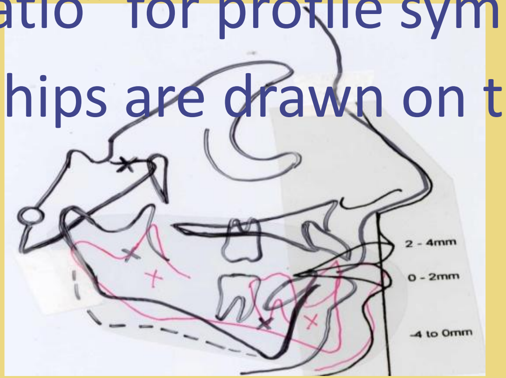
Mark the final positions of the inferior alveolar foramen, mental foramen, and foramen ovale.



Template Usage:

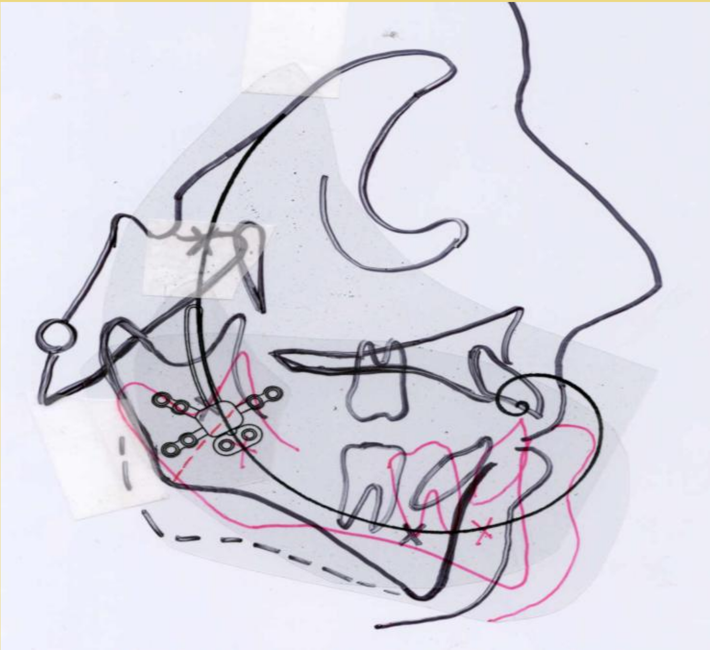
- ✓ Once these regions are identified, the surgical treatment plan is created.
- ✓ It establishes the final positions of the teeth and jaw tip.
- ✓ The “ideal soft tissue ratio” for profile symmetry should be checked; ideal relationships are drawn on the template.

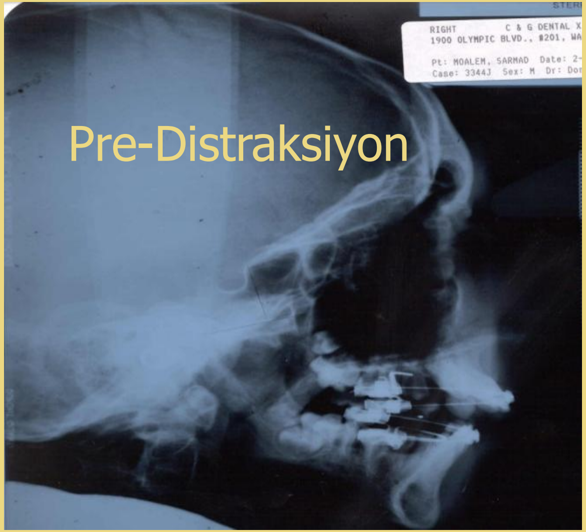




LOGIC™ mandibuler distraktörü

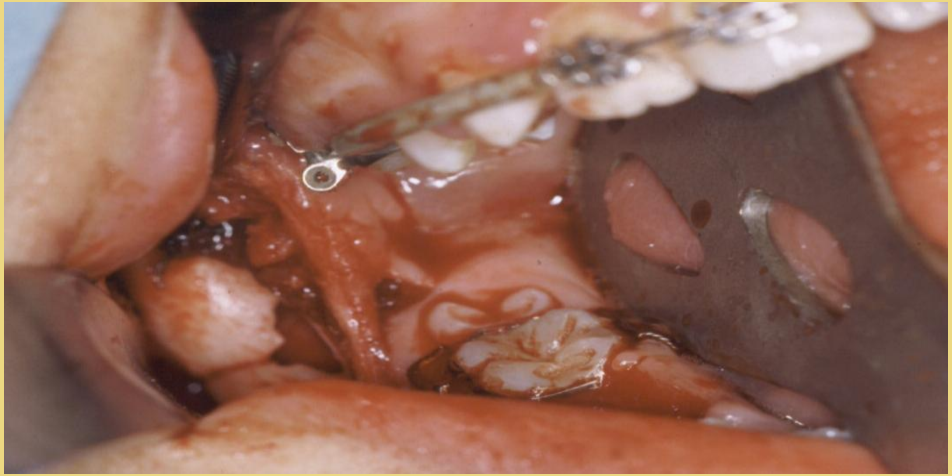
- Şablonun kullanılışı
  - Cerrah distraktörün deliklerini (gövdesini) eğim üzerine getirmelidir ve spirale en iyi uyanın hangisi olduğunu saptamalıdır. Osteotomi pozisyonu da dikkate alınmalıdır. Kesi sinir hattı sinir lokasyonu, diş kökleri hizasında, kemikte olmalıdır.
  - Distraktörün rotasyonel oryantasyonuna özellikle dikkat edilmelidir. Distraktör olması gerekenden daha vertikal ya da horizontal yerleştirilirse o yöne doğru büyüme artar.
  - Uygun distraktörün eğrisi, vida deliği

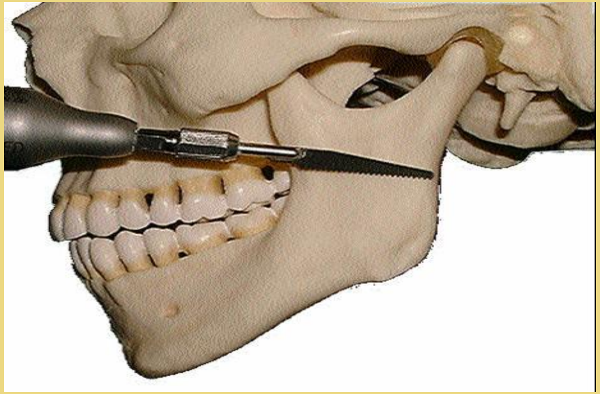
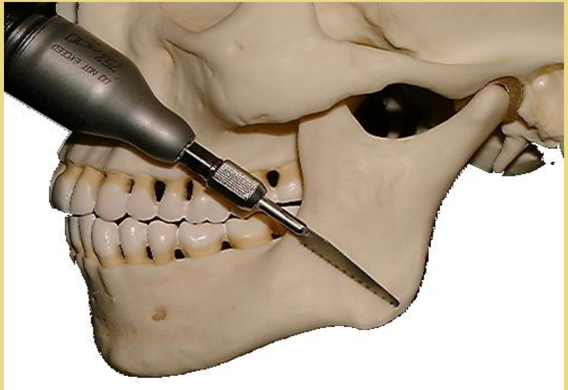
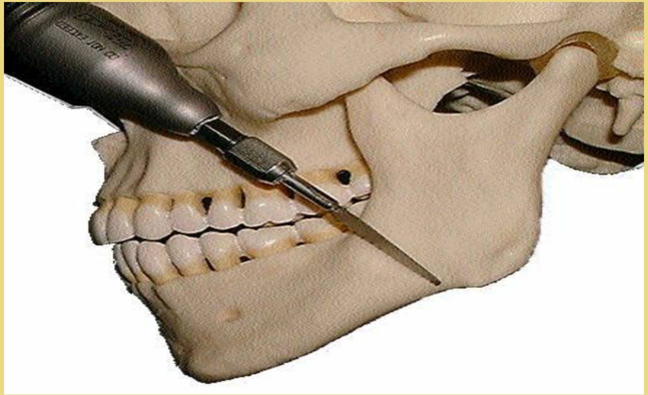


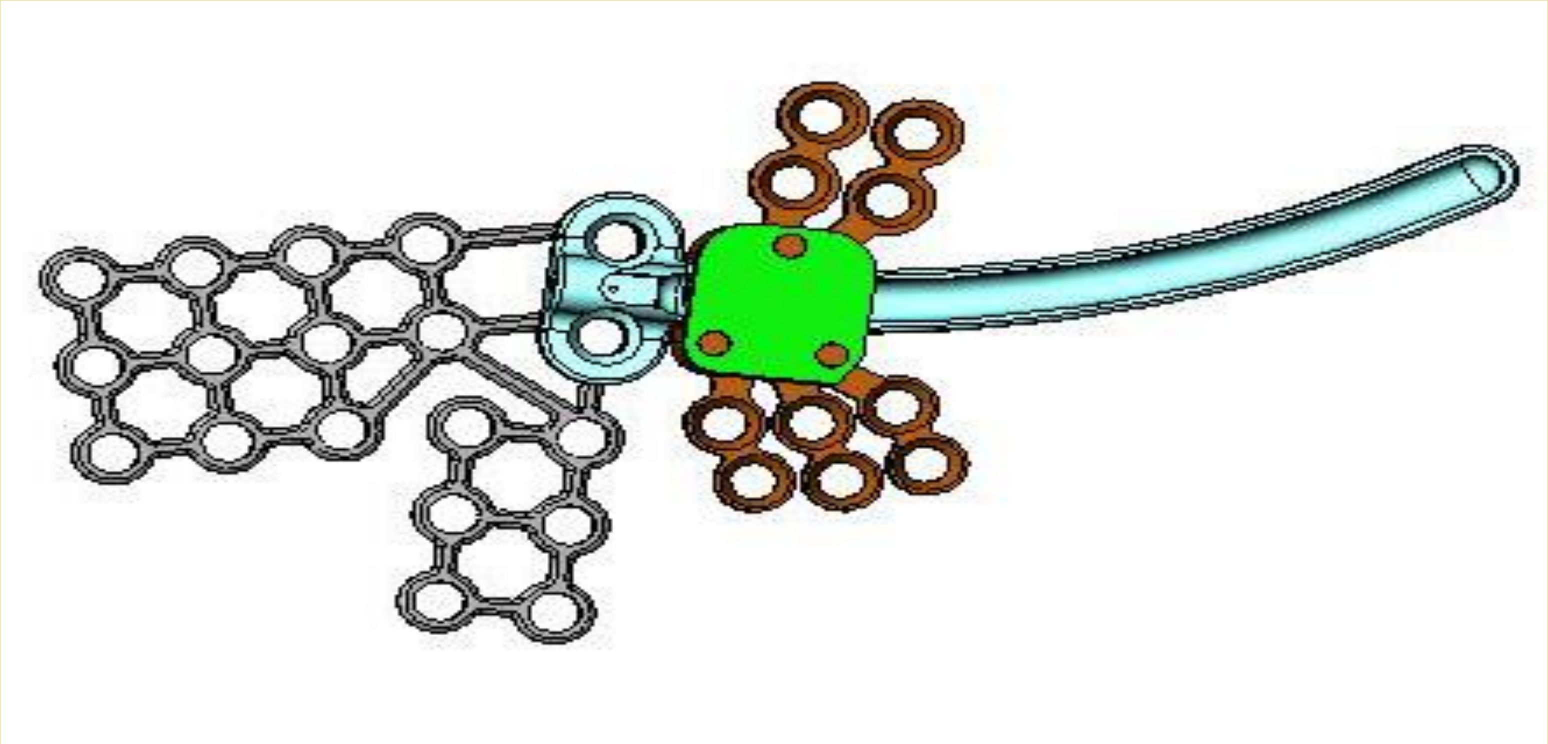

Pre-Distraksiyon


Post-dist; yerleştirildikten
3 days later

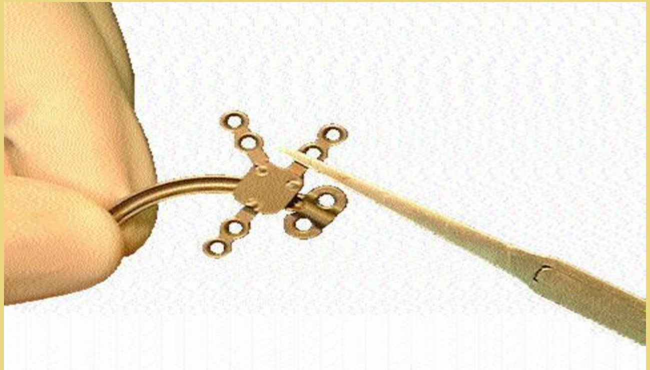

Post-Dist, 4 months

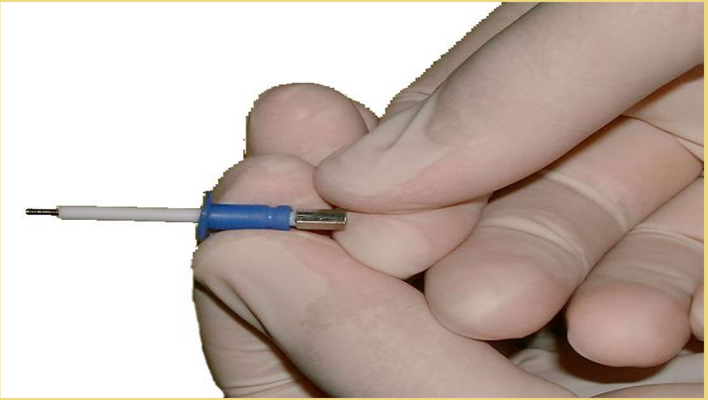


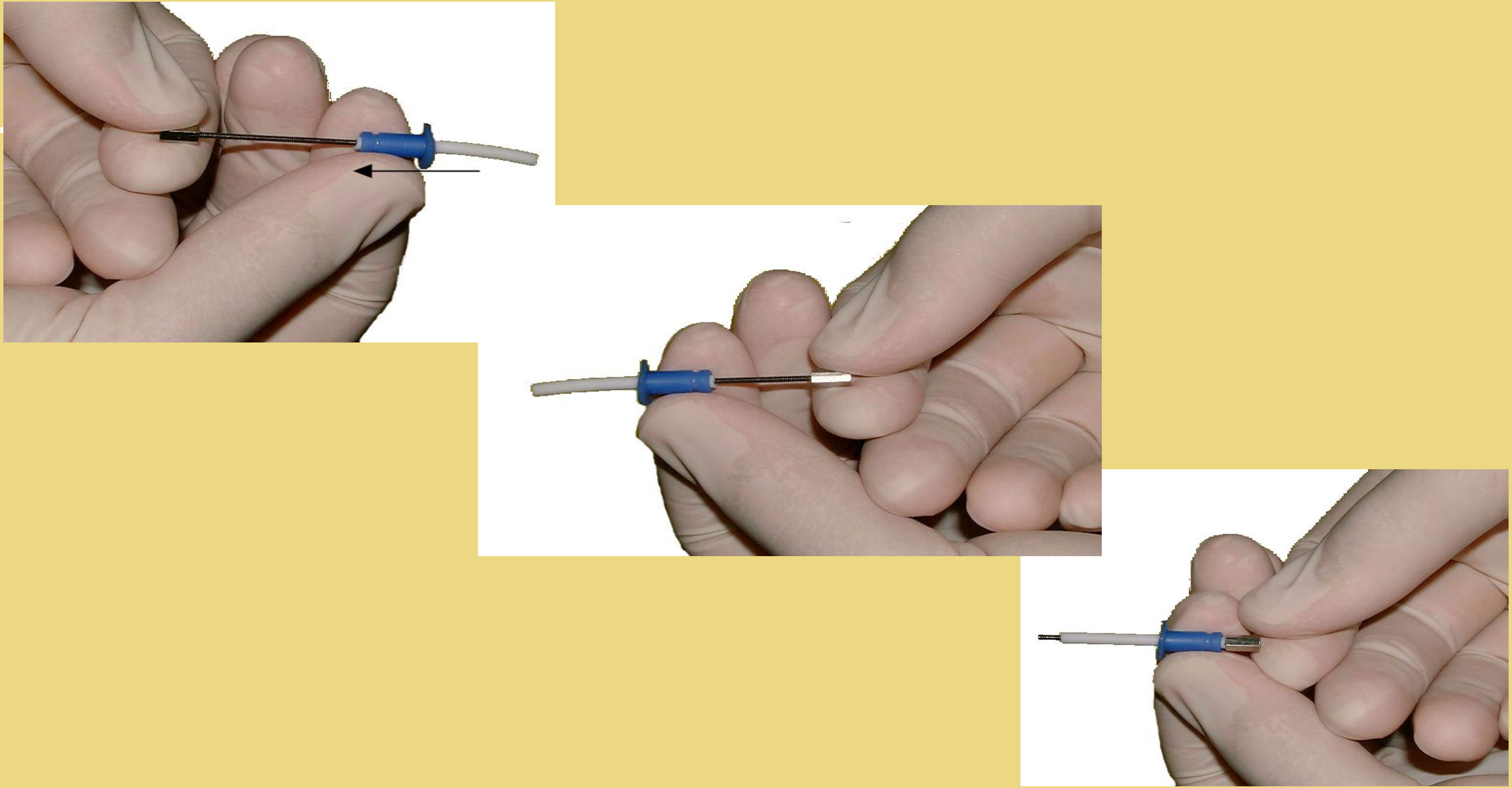


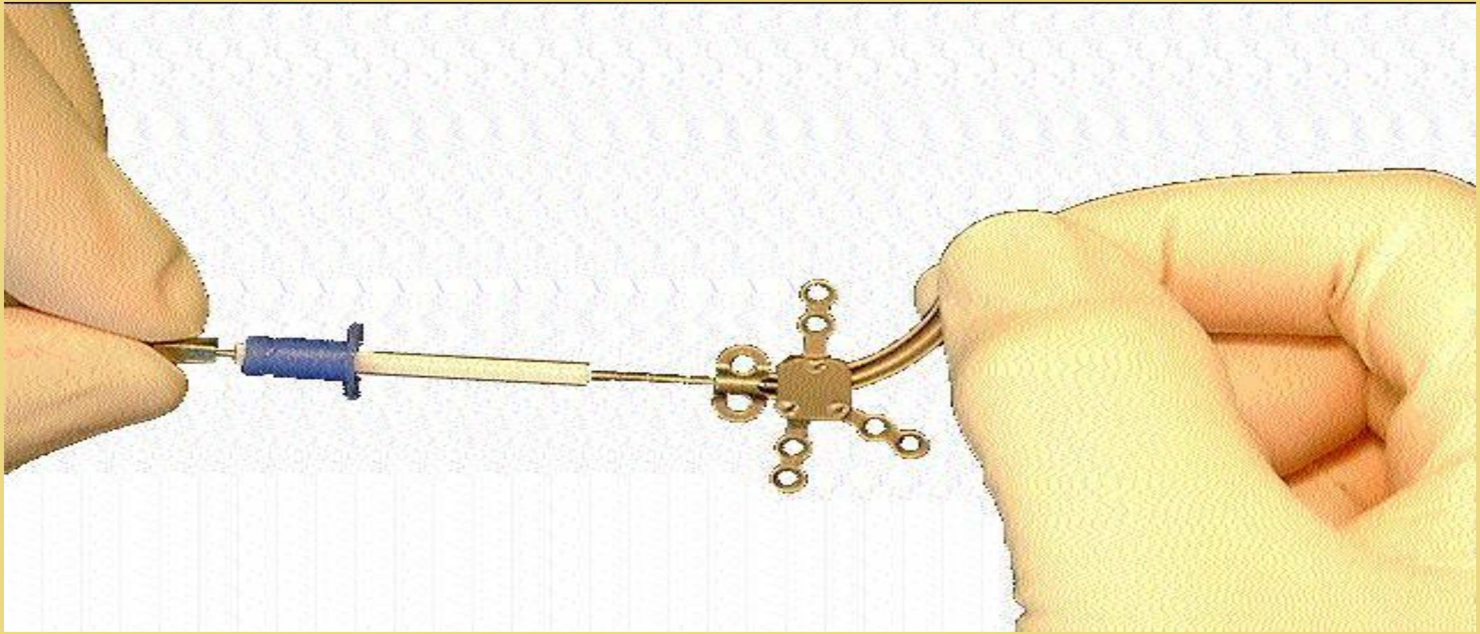
- Surgical Procedure

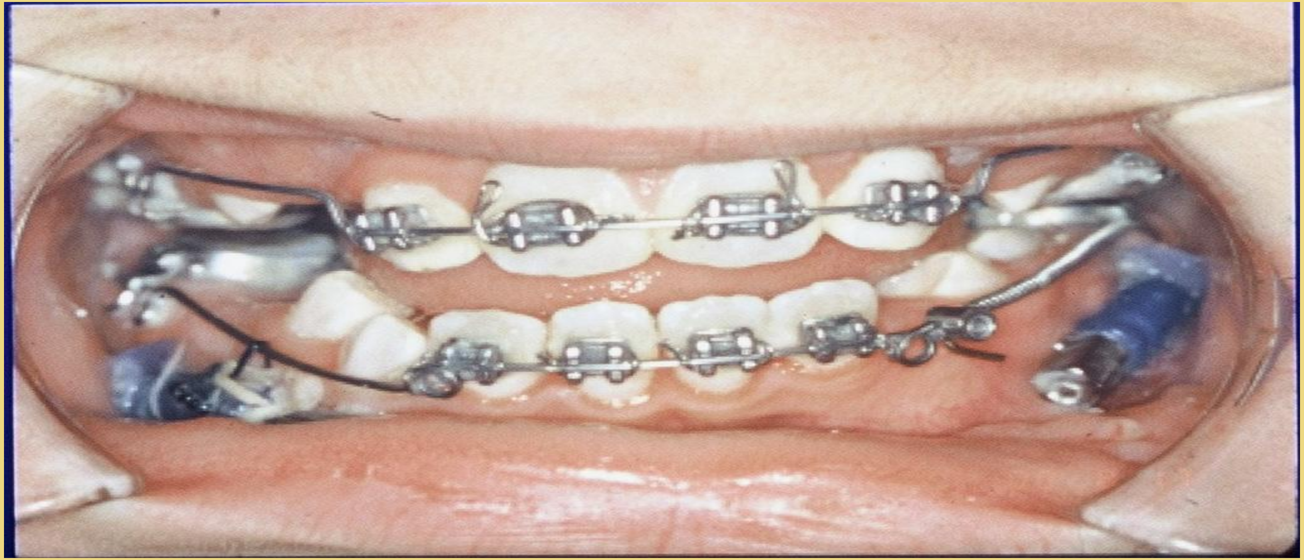




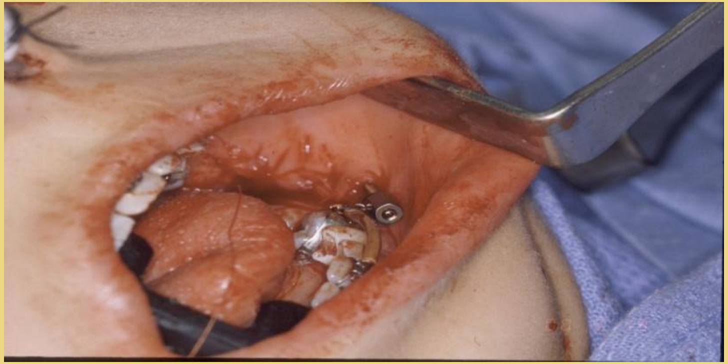
6.

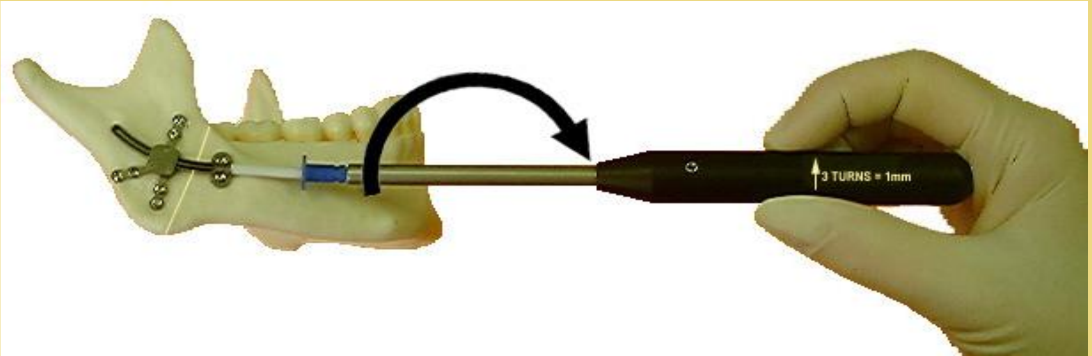


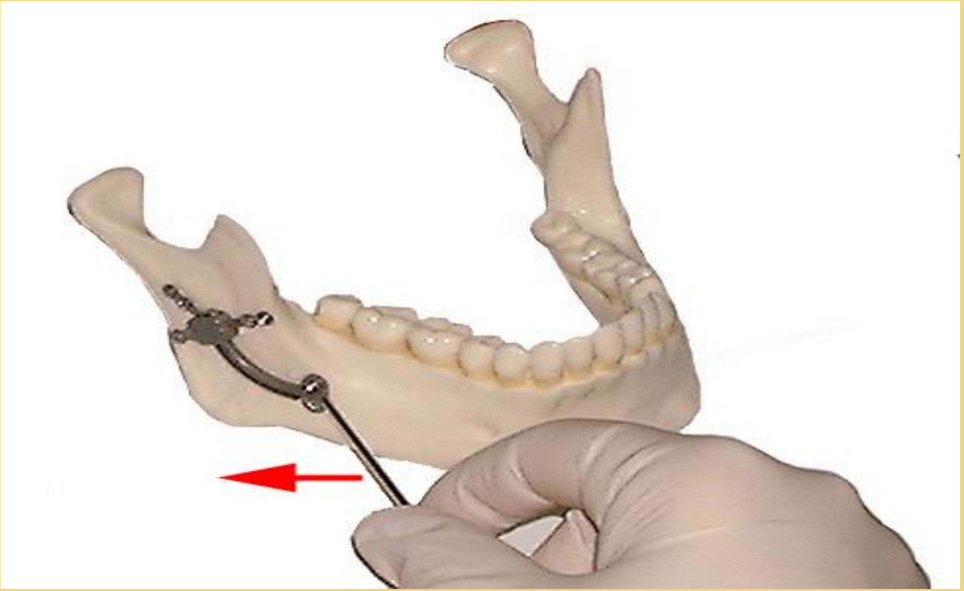


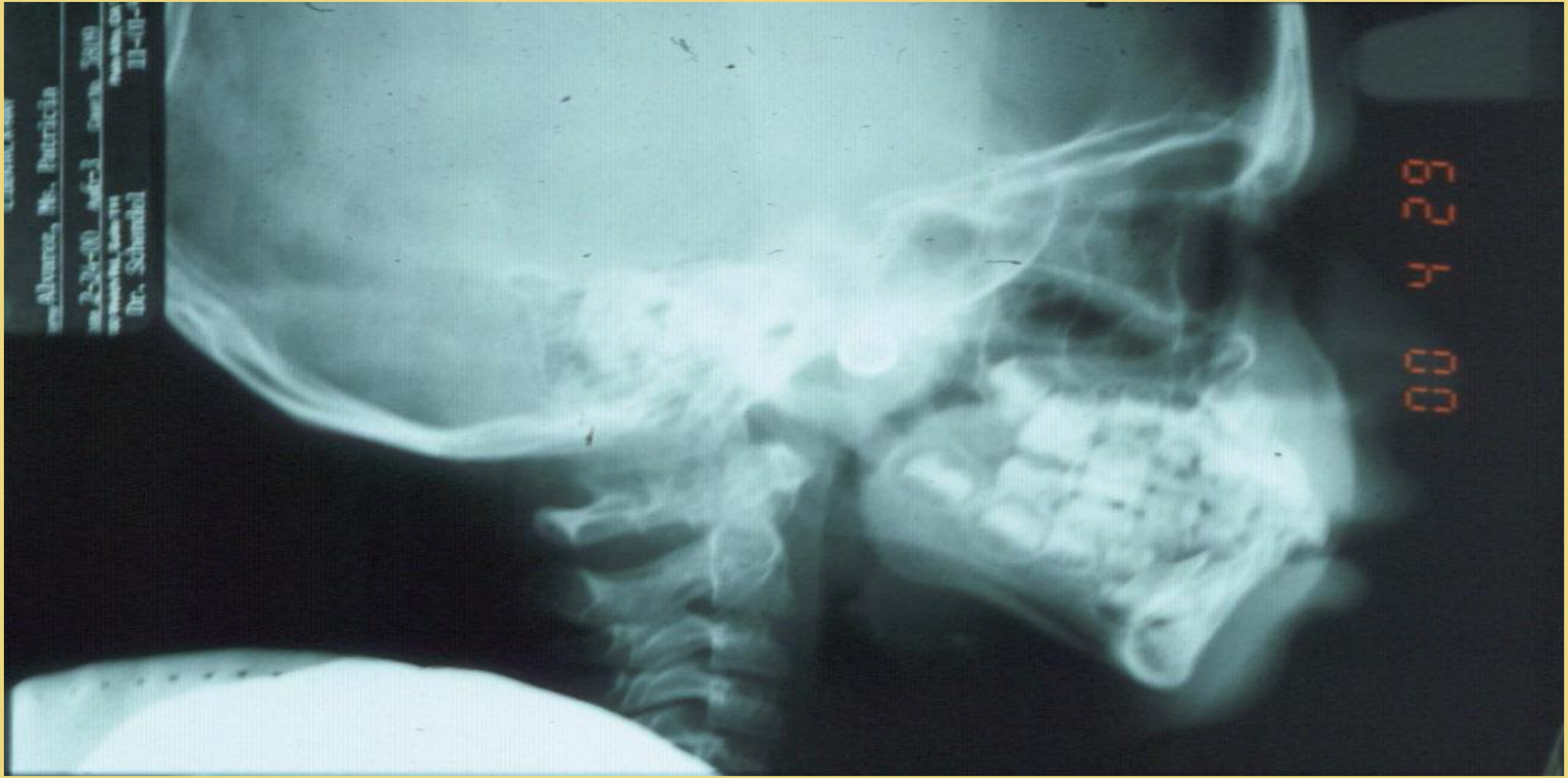


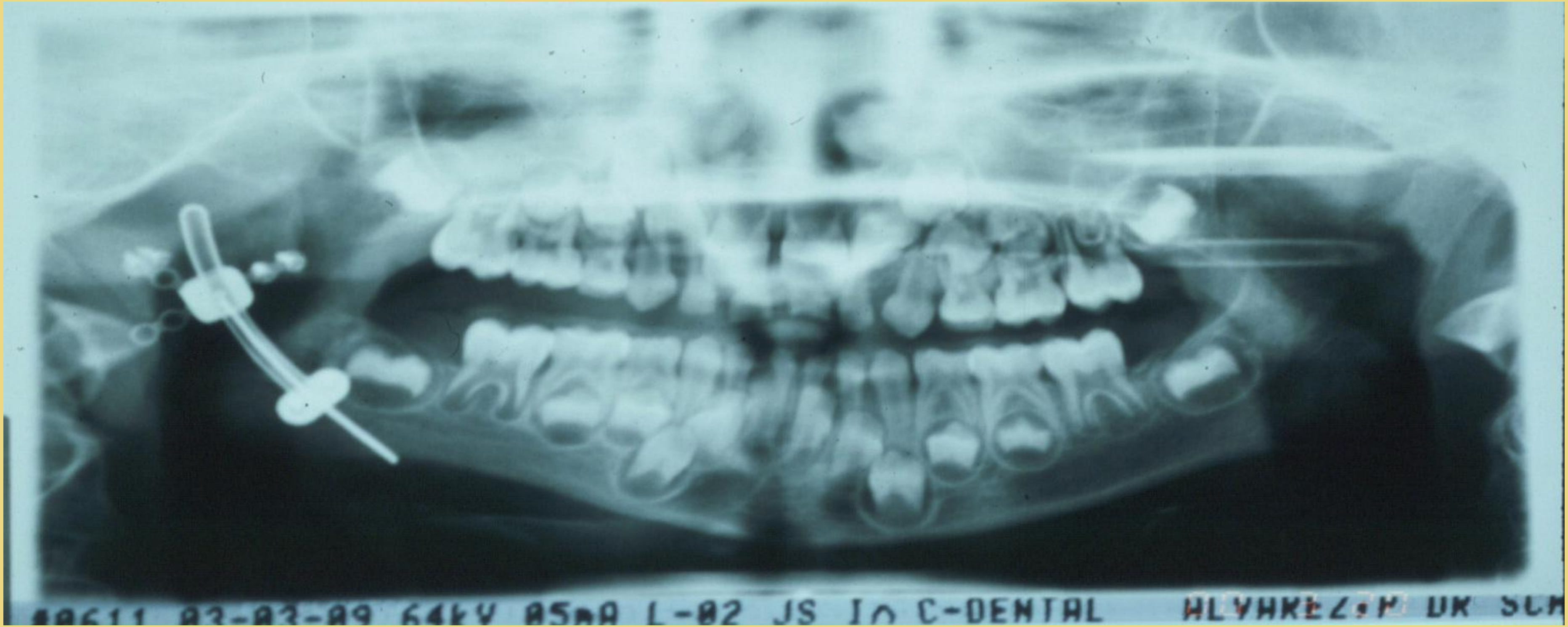
- Extra-oral activation

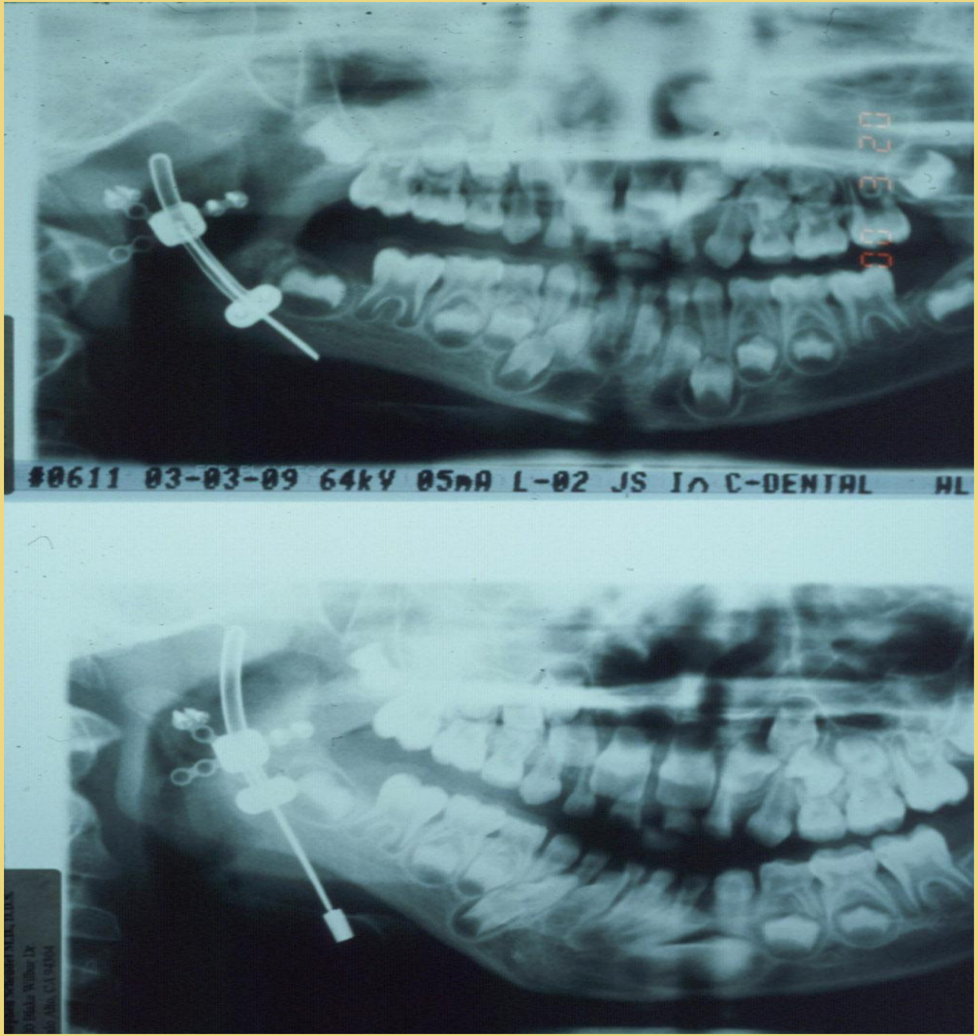


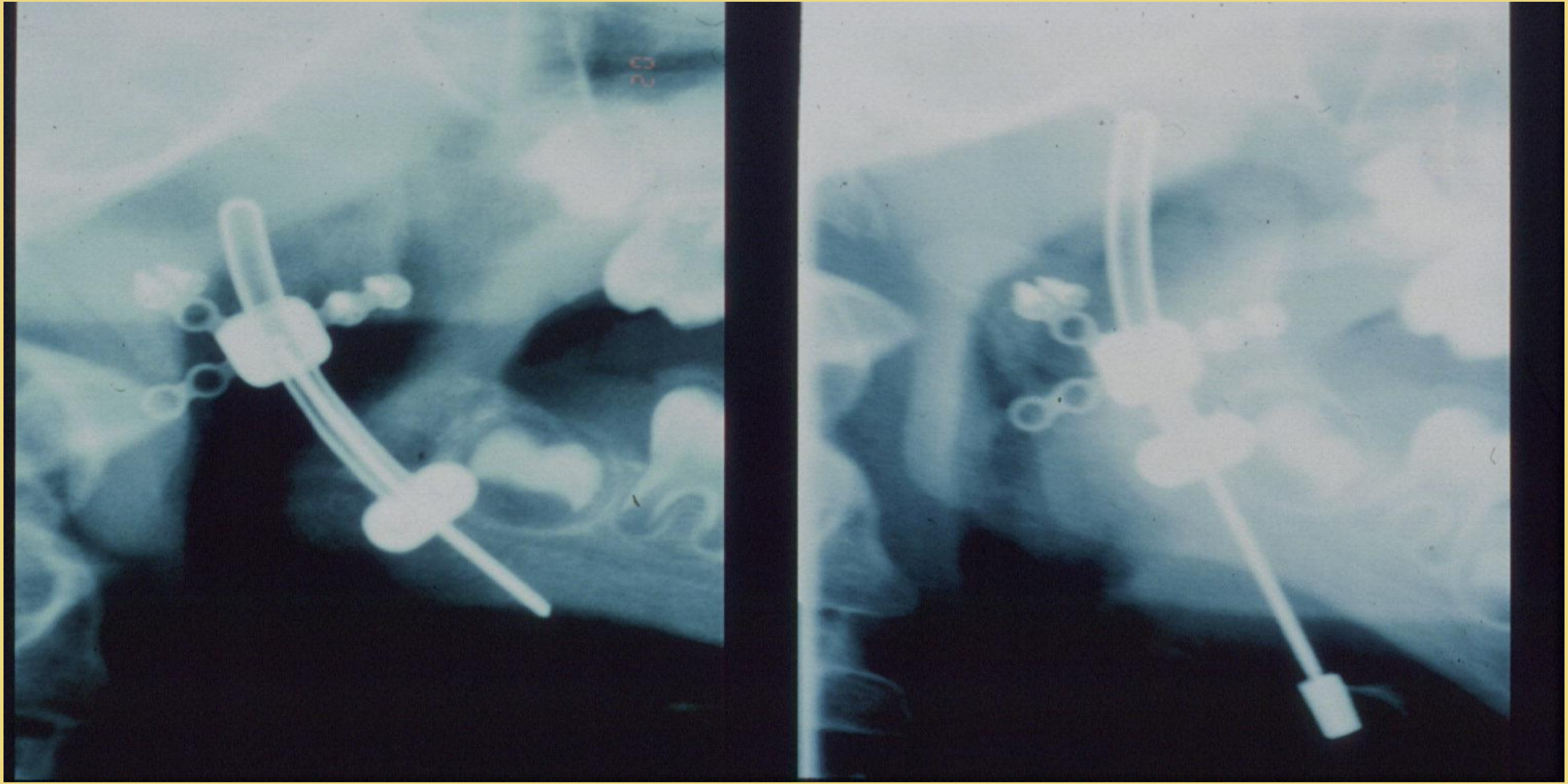

3 TURNS = 1mm

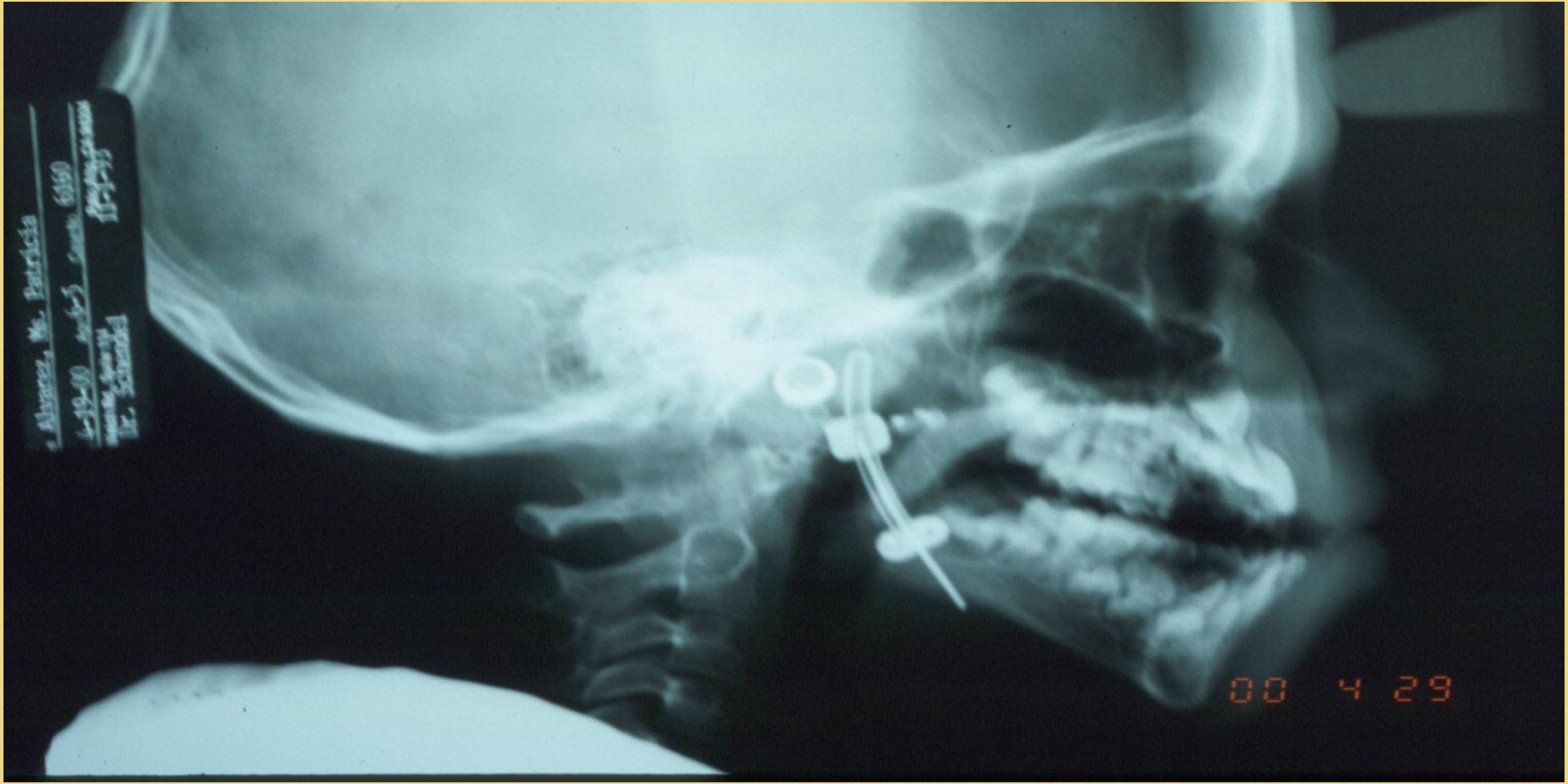



03-03-09 64kV 05mA L-02 JS C-DENTAL


#0611 03-03-09 64kV 05mA L-02 JS
C-DENTAL

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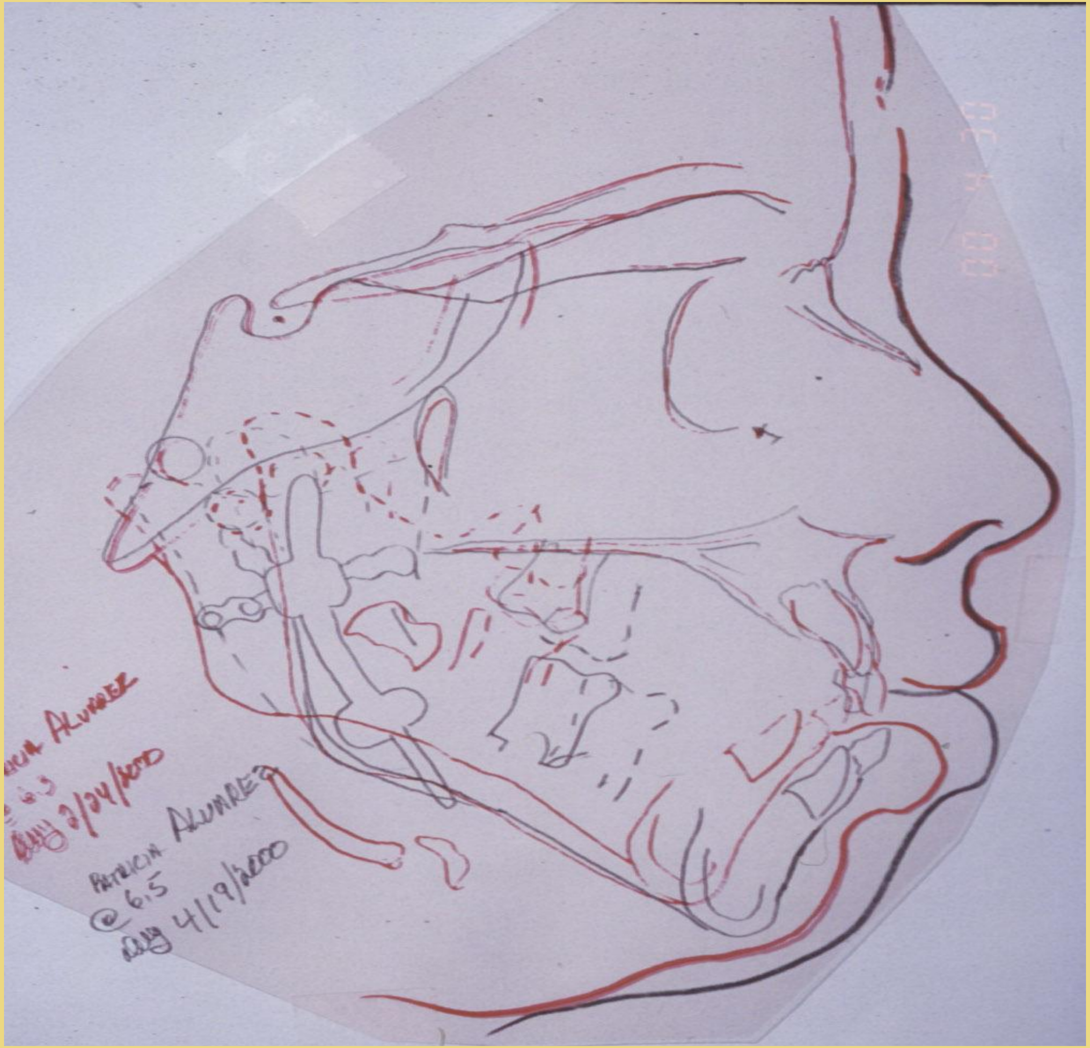
ALVAREZ
6.5
2/24/2000
PATRICIA ALVAREZ
@ 6.5
4/19/2000