EVALUATION OF THREAD DESIGN OF CONVENTIONAL IMPLANT AND INDIGENOUS IMPLANT IN IMPLANT RETAINED AURICULAR PROSTHESIS –IN VITRO STUDY

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(PROSTHODONTICS AND CROWN AND BRIDGE)
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CERTIFICATE

This is to certify that the dissertation titled **"Evaluation of thread design of Conventional implant and Indigenous implant in Implant retained auricular prosthesis –In vitro study"** is a bonafide record of work carried out by **Dr. SRIPRIYA. S**, during the period of 2007-2010. This dissertation is submitted in partial fulfillment, for the degree **of Master of Dental Surgery** awarded by TamilNadu Dr. MGR Medical University, Chennai in the **Branch I Prosthodontics and Crown & Bridge.** It has not been submitted partially or fully for the award of any other degree or diploma.

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INTRODUCTION

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Facial defects can result from trauma, treatment of neoplasm, or congenital malformation. Restoration of facial defects presents a difficult challenge for both the surgeon and the prosthodontist[1].

Clinical experience has shown that neither extrinsic retention nor intrinsic with the use of undercuts and adhesive systems do not provide predictable prosthesis retention[2].

The first study in which a direct bone anchorage was suggested as a clinical possibility was published in 1969 and the term "Osseointegration" was first used[3]. With the introduction of osseointegration to the extra-oral craniofacial complex, in the year 1976 predictable mechanical retention of the facial prosthesis was established."

The first craniofacial osseointegrated implants was based on the experience of previously placed oral implants combined with data gathered from experimental investigations of skin-penetrating implants[4].

The long-term success of craniofacial implants depends on the availability of bone, bone density, implant design and the force distributed over the implant site. Implants used to retain auricular prosthesis were first tried in the year 1979.

Osseointegration is defined as direct connection between bone and implant surface. Titanium is generally stronger and stiffer than the bone. The titanium implant and the bone may be regarded as having a perfect fit with no stress in either material prior to loading. An implant is osseointegrated well when bone is allowed to heal around it in the absence of loading.

Load transfer from implants to surrounding bone depends on the type of loading, the bone to implant interface, the length and diameter of the implants, the thread shape and characteristics of the implant surface, the prosthesis type, and the quantity and quality of the surrounding bone.

Implant design influence the maintenance of osseointegration. The limited availability of bone and close proximity to the anatomical structure dictate the design of the implant to support auricular prosthesis. The placement of the flange can make auricular implant a challenge[5].

Implant threads are used to maximize initial contact, improve initial stability, enlarge implant surface area and improve the dissipation of stresses at the interface[6]. Thread depth, thickness, angle, pitch are some of the geometric variations that determine the functional thread surface and affect the biomechanical load distribution around the implant[7]. The complex geometry of the implants prevents the use of closed-form solutions in stress-analysis, where simple formulas relate the effect of external loads to internal stresses and deformations[8].

A recent innovation in Implant Dentistry to study the Stress and Strain distribution in the bone surrounding the implant follows Finite Element Analysis using software technology. Finite element analysis is a technique for obtaining a solution to a complex mechanical problem by dividing the problem domain into a collection of much smaller and simpler domains or elements in which the field variables can be interpolated with the use of shape functions[9]. Weinstein et al was first to use Finite element analysis in Implant dentistry in 1976[10].

The success and failure of implant is determined by osseointegration, it is a precondition for prosthetic repair through implant. Implant stability can be divided into primary and secondary stability. The primarily stability is obtained by mechanical fixation of the implant with bone, and this is one of the basic conditions for osseointegration.

Primary stability is related with implant surface area, geometry, length, contact area between implant and bone. Other factors include cortical bone, implant technique etc. The secondary stability is generated secondarily by bone formation and bone remodeling in the process of osseointegration due to biological fixation in the interface between bone and implant. Therefore it is possible to evaluate the degree of osseointegration through the measurement of changes in the implant stability[11].

Resonance Frequency Analysis (RFA) is a method used to determine the stability in dental implants. Meredith who invented the resonance frequency device, reported on the use of the resonance frequency analyzer to evaluate the stability of implant .The stability is presented as an implant stability quotient value. The higher the implant stability quotient value (ISQ) the higher the stability[12].

Recently, histomorphologic studies suggested that the resonance frequency value has a high correlation with the level of contact between bone and implant. This discovery supports the use of resonance frequency analysis to evaluate the changes in the process of osseointegration and bone healing after placement of implant.

The resonance frequency analyzer can measure clinically and noninvasively the stability of implant and estimate the degree of osseointegration.

Hence it was decided to conduct an in-vitro study to evaluate and compare the stress distribution and stability to the temporal bone in relation to thread shape, length and diameter of craniofacial auricular implants, which is commercially available in the market with that of indigenous craniofacial auricular implant.

The aim of this study was to evaluate the design parameters of auricular implant thread shape, diameter and length on stress distribution in the surrounding temporal bone by Finite Element Analysis and to evaluate the primary stability in the goat skull by Resonance Frequency Analysis.

The objectives of the study included the following:

1. To evaluate the influence of the stress distribution in the temporal bone region by keeping the diameter constant and by varying length using conventional auricular implant V –shape thread design and indigenous auricular implant of Buttress- shape thread design by Finite Element Analysis.
2. To compare and evaluate the influence of stress distribution in the temporal bone region using conventional auricular implant V-shape thread design and indigenous auricular implant of Buttress-shape thread design by Finite Element Analysis.
3. To evaluate the primary stability of the auricular implant by placing in the goat skull using conventional auricular implant V –shape thread design, and indigenous auricular implant of Buttress- shape thread design by Resonance Frequency Analysis.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

- **Farah JW, Craig RC (1974)** [13]worked to produce an article "Finite element analysis on a restored axi-symmetric first molar" and created history by bringing finite element method (FEM) study in dentistry for the first time, proving its efficiency to be better than photo elastic study in terms of easy modeling and more defined stress analysis. Since then finite element method (FEM) is widely used in dentistry.

- **Borchers L, Reichart P (1983)**[14] used the finite elements method to analyze the stresses generated by a ceramic implant. Higher stresses were observed in the region of the alveolar crest, mainly when the implant was submitted to transverse loads. They observed also that the presence of hard lamina or conjunctive tissue around the implant helps to reduce those stresses.

- **Lekholm U, Dr. Odont (1983)**[15] osseointegrated pure titanium implants of defined finish and geometry have been used clinically as abutments for dental prostheses for more than 17 years. The clinical procedures involved in the osseointegration are not difficult to accomplish ever, they must be performed with the least trauma and the highest precision possible.

- **Per Ingvar Branemark (1983)**[3] since 1952, studied the concept of tissue integrated prostheses .The initial concept of osseointegration stemmed from vital microscopic studies of the bone marrow of the rabbit fibula, which was uncovered for visual inspection in a modified intravital microscope at high resolution in accordance with a very gentle surgical preparation technique.

- **Bengt Kasemo, Jukka Lausmaa (1988**)[16] when a biological system encounters an implant, reactions are induced at the implant-tissue interface. This article deals with various surface properties that are expected to influence tissue implant reactions and methods available for implant surface characterization. Results of this type are valuable for basic research concerning implant-tissue reactions as well as production control and implant standardization.

- **Rieger M R (1988)**[17] finite element analysis comparisons between implants. The finite element method has been used for many years to solve civil, mechanical, petroleum, and structural engineering problems. Tesk and Widera evaluated two blade type and one post type dental implants using FEM. The post-type implant transferred most of its load to the crestal bone. Buch used FEM to evaluate the biomechanics of natural teeth, ankylosed teeth, and various tooth-substitute combinations.

- **Rieger M R, Fareed K (1989**) [18]Axisymmetric finite element models of three geometries were evaluated .A serrated solid with a 2 degree taper and a rectangular cross section; a cylindrical screw type solid; and a finned solid with a 1 degree 9' taper and a circular cross section. The results indicated that the serrated geometry led to high stress concentrations at the tips of the bony in growth and near the neck of the implant. The design must not cause high stress concentrations at the implant neck that commonly cause bone resorption.

- **Rieger M R et al (1990)** [19]based on the works of HASSLER et al (1977), proposed an ideal load of 250 psi to be transmitted to the bone with implants. Regions with values below 200 psi would be subject to atrophy and above 400 psi to pathologic resorption.

- **Rieger et al (1990)**[20] analyzed eleven different post type endosseous implants to compile a list of features that could be used to design an optimal post-type endosseous implant. Stress magnitudes and contours within each implant and surrounding bone were calculated. Implant features causing high stresses and low stresses, possibly contributing to pathologic bone resorption and bone atrophy were noted. Concluded that (1) low stresses can be as problematic as high stresses, bone resorption can occur in both circumstances; (2) larger implants do not make better implants(3) to avoid punching stresses, tapered implants are better than cylindrical implants.

- **N.L. Clelland et al (1991)**[21] the three-dimensional finite element stress analysis method was used to determine the pattern and concentration of stresses within the Screw-Vent endosseous implant and its supporting tissues. They concluded (1).All of the stress contour drawings showed no stress in the apical portion of the implant or it's supporting osseous tissue. (2.) Maximum stresses in the implant were located in the implant collar immediately. (3.) Maximum stresses in the implant were well within the endurance limit of commercially pure titanium (259.90 MPa). Based on the finite element model of the implant, the metal will not fatigue under normal occlusal forces.

- **Meijer H J et al (1992)**[22] investigated the stress distribution around dental implants by the use of a two-dimensional model of the mandible with two implants. A vertical load of 100 N was imposed on abutments or the bar connection. The stress was calculated for a number of superstructures under different loading conditions with the help of the finite element method. The length of the implants and the height of the mandible were also varied. Using shorter implants did not have a large influence on the stress around the implants. When the height of the mandible was reduced, a substantially larger stress was found in the bone around the implants because of a larger overall deformation of the lower jaw.

- **Craig M et al (1993)**[23] this study was to conduct a three dimensional finite element stress analysis to compare models representing a natural tooth and an integrated implant connected with rigid and nonrigid prostheses. Based on the similarities in both the pattern of stress contours and the stress values generated in the two models, advocating a nonrigid connection because of a biomechanical advantage may be erroneous.

- **Nancy L Clelland et al (1993)**[24] biocompatibility and biomechanics are two of the important factors in the success of dental implants. Two and three dimensional finite element analyses have been used to analyze stress distributions in various implant designs using a model of the mandibl. This study was to use a simple, time efficient, axisymmetric model to determine the effect of various bone parameters on the stresses and strains generated in bone under occlusal loading of a dental implant.

- **Arthur M Rodriguez et al (1994)**[25] a summary of the literature regarding the determination of acceptable cantilever lengths for fixed implant prostheses is presented. Studies examining the possible effects of biomechanical stress on both the implant prosthesis and the supporting bone are also discussed.

- **David C Holmes (1994)**[26] the finite element method was used to model a 4.0 x 13.0 mm IMZ implant restored with a cast gold crown to examine the relationship between deflection of the prosthetic superstructure and stress concentrations. A strong correlation was observed between the peak stresses in the screw and the deflection of the superstructure. Deflections and stress concentrations generally increased with increases of either the load magnitude or the load angle. Greater deflection and stress concentrations within the coronal retaining screw were predicted with the use of the resin IME than with the titanium element.

- **Nancy et al (1995)**[27] three-dimensional mathematical model of the maxilla was developed to analyze the stresses and strains produced by an abutment system. There was an increase in the magnitude of stress and strain as the abutment angulations increased. Reported stresses and strains for all three angles were within or slightly above the physiological zone derived from animal studies. A need to investigate the response of human bone to stress and strain was indicated.

- **Atilla Sertgoz (1996)**[28] study investigated the stress distribution at the bone/ implant interface with a three-dimensional finite element stress analysis by using three different cantilever and implant lengths in an implant-supported fixed partial denture. Simulation models were created as a bilateral distal cantilever fixed partial denture supported with six implants embedded in a model of the mandibular bone. Nine different simulation models had three different cantilever (7, 14 and 28 mm) and implant lengths (7, 15, and 20 mm). Vertical forces of 75 N and horizontal forces of 25 N were applied to the distal end of the cantilever. Analysis of the von Mises stresses for the bone was done. However, there was no statistically significant change associated with the length of implants.

- **Ch Malevez et al (1996)**[29] marginal bone levels at Branemark system implants used for single tooth restorations : The influence of implant design and anatomical region. Different implant designs were used, a more pronounced bone loss was observed for the conical implant. The present data shows that the cumulative failure rate for single Branemark implants and the radiographic bone loss is similar to that found around implants used for the treatment of complete and partial edentulism.

- **Lai H C (1997)[30]** the effect of the length of implants on stress distribution is one of the important subjects in implantology. In this study, three dimensional finite element methods model was constructed by dental CT images, the purpose of this study was to evaluate the stress distribution in bone adjacent to an implant after application of loading in horizontal, oblique and vertical direction. It was show that the highest stress occurred at the cervical bone margin adjacent to the implant only 10% decreases in inverse two times increase in implant length, and correlated little to the implant length, therefore, it was unnecessary to emphasize the length of the implants in clinic.

- **Victor del Valle et al (1997)**[5] strain distributions that occur in the hard tissue in the region surrounding craniofacial osseointegrated implants are compared. Three commercially available implant designs were evaluated under both axial loading and axial loading with a moment in three bone configurations typical of the craniofacial region. The evaluations that used the finite element method indicated that for axial loading, the implant designs produced similar strain levels in each bone configuration. When moments as well as vertical loads were applied, the strains were three to seven times higher and variations among the designs were greater. The variations found were related to the amount of bone present in each situation, as well as the neck diameter of the implant involved.

- **Holmgren et al (1998)** [31]after a finite element study suggested that (1) using the widest diameter implant is not necessarily the best choice when considering stress distribution to surrounding bone, but within certain morphological limits, an optimum dental implant exists for decreasing the stress magnitudes at the bone implant interface; (2) it is important in finite element analysis to consider not only axial forces (vertical loading) and horizontal forces (moment causing loads), but also to consider a combined load (oblique bite force), since these are more realistic bite directions and for a give force will cause the highest localized stress in cortical bone; (3) clinically, wherever possible, an optimum, not necessarily larger, implant should be used based on the specific morphological limitations of the mandible

- **Roxana Stegaroiu(1998)**[32] The three-dimensional finite element analysis method was used to assess stress in bone around titanium implants using three treatment designs for a partially edentulous mandible, under axial (AX), buccolingual (BL), or mesiodistal (MD) loads. For each of these loads, highest stress was calculated in the model with cantilever prosthesis Supported by two implants (M2). Less stress was found in the model with a conventional fixed partial denture on two implants (M3), and lowest stress was calculated in the model.

- **Carl et al (1999)**[33] this interim report presents the data from a prospective study of BioHorizons, a bone quality based implant system, with four implant designs. This study suggests the bone quality based dental implant design minimizes overall implant failure and crestal bone loss, regardless of bone density.
- **Sato et al (1999)**[34] to investigate the effectiveness of element downsizing on the construction of a three dimensional finite element bone trabeculae model, with different element sizes (600, 300, 150 and 75 um) models were constructed and stress induced by vertical 10N loading was analysed. Downsizing of elements from 600 to 300 um is suggested to be effective in the construction of a three dimensional finite element bone trabeculae model for possible saving of computer memory and calculation time in the laboratory.

- **Daniel et al (2000)**[35] computer aided design and finite element methods (FEM) have interested dental researchers because of its use in the computer simulation and design of dental implants, a process greatly facilitated by the development of new computer technology and more accurate modeling technologies. FEM allows for a better understanding of stresses along the surfaces of an implant and in surrounding bone. This will aid in the optimization of implant design and placement of the implant into the bone; it will also help when designing the final prostheses to minimize stresses.

- **Tan, Jiang Ping et al (2001)**[10] studied that FEA has been used extensively to predict the biomechanical performance of various dental implant designs as well as implant success. This article reviews the current status of FEA application in implant dentistry.

- **Thomas D Taylor et al (2002)**[36] prosthodontics focus on the restoration of osseointegrated dental implants has evolved dramatically in the last 20 years. It is appropriate that this evolution be examined with a 2 fold focus. First, the art and science of prosthodontics as it relates to dental implants .Second, relates to osseointegration gives insight into the future direction of research and clinical exploration aimed at continually improving the state of the art, and ultimately, the quality of care provided to patients. This article reviews what the authors consider the most important aspects of the evolution of osseointegrated implants.

- **Akagawa et al (2003)** [37]study was to develop a new three dimensional (3D) mimic model of an osseointegrated implant for finite element analysis (FEA) and to evaluate stress distributions in comparison with a model commonly used in most studies as a control. Biomechanics is one of the most important factors for the long term stability of an osseointegrated implant, because mechanical stress by functional loading inevitably influences long term peri implant bone remodeling (Albrektsson, 1983; Hoshaw, Brunski & Cochran, 1994). Finite element analysis (FEA) has been widely applied to studies on stress distribution in the bone around the loaded osseointegrated implant and these studies show that induced stress by vertical and/or oblique loading is mostly concentrated at the crestal bone.

- **Allahyar Geramy et al (2004)** [38] study was to develop a finite element model of a single mandibular first molar crown supported by (1) a standard 3.75 mm – diameter implant, (2) a 5 –mm, wide diameter implant, and (3) double standard diameter implants, and to compare the induced displacements as a result of various loading conditions. When the crown was loaded off center, the double implant design produced substantially less displacement when compared with either of the single implant designs.

- **Choi A H, Ben Nissan B (2005)**[39] study was to improve the method of modeling by using computer aided engineering (CAE) and computer aided design (CAD) methods and to utilize the model in analyzing maxillofacial problems. This investigation has shown that the use of computer aided modeling in conjunctionh with the finite element analysis could be effectively utilized in biomechanical analysis of the mandible. It could help to investigate many functional problems and could reduce the time of extensive experimentations.

- **Li Shi, Beng, Haiyan Li et al (2007)**[40] study was to derive alternative implant shapes which could minimize the stress concentration at the shoulder level of the implant. A topological shape optimization technique (soft kill option), which mimics biological growth, was used in conjunction with the finite element (FE) method to optimize the shape of a dental implant under loads. Shape optimization of the implant was carried out using a 2-dimensional (2D) FE model of the mandible. Three dimensional (3D) FE analyses were then performed to verify the reduction of peak stresses in the optimized design. The new implant shapes obtained using FE based shape optimization techniques can potentially increase the success of dental implants due to the reduced stress concentration at the bone implant interface.

- **Goran Bergkvist et al (2008)** [41]this study used the finite element method (FEM) to simulate stresses induced in bone tissue surrounding uncoupled and splinted implants in the maxilla because of bite force loading, and to determine whether the differences in these stress levels are related to differences in observed bone losses associated with the two healing methods. From a mechanical viewpoint, FEM simulation supports the hypothesis that splinting reduces damage evolution in bone tissue, which agrees with clinical observations.

- **Hung Chan Kao et al (2008)**[42] to investigate the micromotion between the implant and surrounding bone caused by the implementation of an angled abutment. Within the limits of the present finite element analysis study, abutment angulation up to 25 degrees can increase the stress in the peri-implant bone by 18% and the micromotion level by 30%.

MATERIALS AND METHODS

MATERIALS AND METHODS

This study was conducted to evaluate the stress concentration in the temporal bone region surrounding the craniofacial auricular implant in relation to different thread shape design and length which was commercially available and indigenously made. The finite element analysis is the most accepted and reliable method to evaluate the stress distribution.

The study was also conducted to determine the primary stability in the fresh goat maxilla in relation to different thread shape design of craniofacial auricular implant which was commercially available and indigenously made. Resonance Frequency Analysis is a method used to determine the stability in dental implants.

MATERIALS: **TABLE 1**

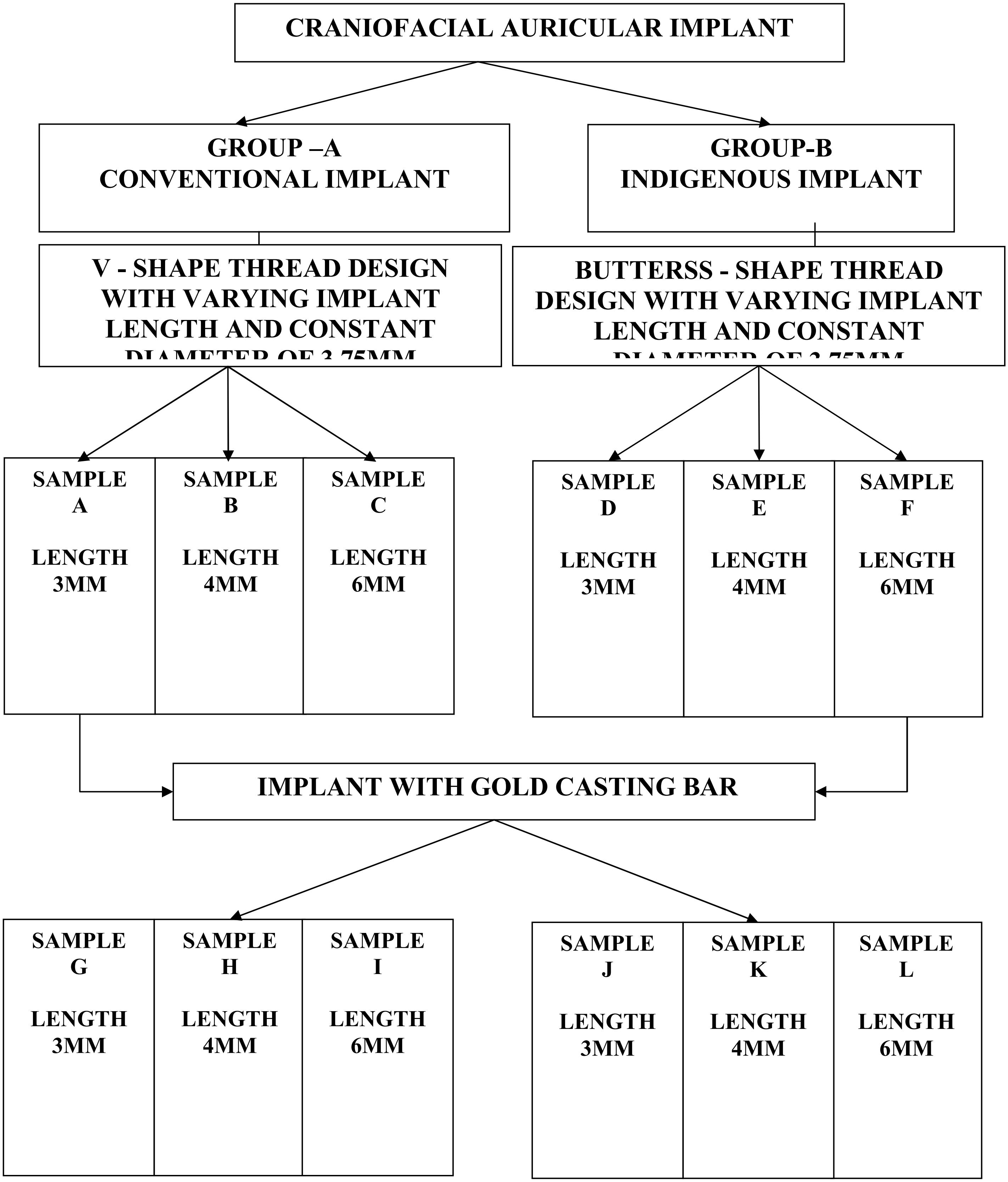
S.NO	IMPLANT	DESIGN	MANUFACTURERS'S NAME
1	Titanium Craniofacial Auricular Implant	V –Shape thread design	Southern Implant , Irene, South Africa
2	Titanium Craniofacial Auricular Implant	Buttress-Shape thread Design	Indigenous implant, Chennai, Made in India

TABLE 2

S.NO	MAIN COMPONENT OF FINITE ELEMENT ANALYSIS
1	Element - Entity joining nodes and forming a specific shape such as quadrilateral or triangular etc. is known as Element.
2	Meshing – Group of element is called Meshing.
3	Nodes - work like atoms and with gap in between filled by an entity called as element.

TABLE-3

S.NO	MAIN COMPONENT OF RESONANCE FREQUENCY ANALYSIS	
1	Transducer	L shaped device which is connected to implant / abutment by a screw
2	Piezo element	Consists of transducer
3.	Implant Stability Quotient	Measurement Unit for implant stability


CRANIOFACIAL AURICULAR IMPLANT
GROUP –A CONVENTIONAL IMPLANT
GROUP-B INDIGENOUS IMPLANT
V - SHAPE THREAD DESIGN WITH VARYING IMPLANT LENGTH AND CONSTANT DIAMETER OF 3.75MM
BUTTERSS - SHAPE THREAD DESIGN WITH VARYING IMPLANT LENGTH AND CONSTANT DIAMETER OF 3.75MM
SAMPLE A LENGTH 3MM
SAMPLE B LENGTH 4MM
SAMPLE C LENGTH 6MM
SAMPLE D LENGTH 3MM
SAMPLE E LENGTH 4MM
SAMPLE F LENGTH 6MM
IMPLANT WITH GOLD CASTING BAR
SAMPLE G LENGTH 3MM
SAMPLE H LENGTH 4MM
SAMPLE I LENGTH 6MM
SAMPLE J LENGTH 3MM
SAMPLE K LENGTH 4MM
SAMPLE L LENGTH 6MM

CONVENTIONAL CRANIOFACIAL IMPLANT

The conventional craniofacial implant auricular implant, marketed by Southern Implant, South Africa is selected as a control group. These implants are machined from "Unalloyed Titanium for surgical implant application" Grade IV titanium was used. The material chosen for these IE implants makes them extremely tough and resistant to fatigue failure.

INDIGENOUS CRANIOFACIAL IMPLANT

Grade II titanium was procured from, Madhani, Labs, Hyderabad for making indigenous maxillofacial implant. Thread shaped made was buttress shape design. The drawing of the procured Craniofacial Implant was drawn on the computer using CAD 2004 software. Data's of the drawing drawn was fed into the Computerized Numerical Control (CNC) milling machine – Lokesh, CNC Machine Hyderabad.

Procedure involved in fabrication indigenous craniofacial implant:

1. Rod Feeding
2. Step turning
3. Threading
4. Parting

Anterior rotational component in the craniofacial implant (external hex) was made by vertical machining centre (VMC). The steps involved are:

1. Centering
2. Drilling
3. Tapping

<u>Method of Fabrication of Drills:</u> The drill was made using stainless steel. The steps involved in fabrication of drills are:

1. Rod Feeding
2. Step turning
3. Grinding by procedure – called drill cutting flute.

The dimensions of the drill for craniofacial auricular implant for pilot drill ϕ 2.2mm round bur with the next drill of dimensions ϕ 2.3, ϕ 2.5, and ϕ2.8 respectively. This bur has a small extension at the shank to provide countersink for the flange of the auricular implant. A customized ratchet was made using stainless steel to drive the implant into the bone.

INSTRUMENTS USED FOR FINITE ELEMENT ANALYSIS METHOD

1. **Optical comparator** (Deltronics corp., USA) - for measuring the profile of the implant.

2. **Personal computer configuration**:

Monitor - HCL TFT LCD MONITOR

CPU - HCL Workstation

Processor - INTEL CORE 2 Duo

Memory Capacity -PRIMARY-1GB, SECONDARY-80 GB

Graphics Card - NVIDIA Quadro FX 370

3. **Software specification:**

Implant modeling – PRO/E WILDFIRE 4.0 (P T C., USA).Meshing and analyzing the implant - **ANSYS** workbench 11.0, (ANSYS inc., USA).

METHODOLOGY

This simulation study was conducted to evaluate the influence of craniofacial auricular implant of varying length and thread shape design on stress distribution in the temporal bone region. The finite element method is a computer aided mathematic technique for obtaining numerical solutions used to predict the response of physical systems that are subjected to external force. It has been suggested as an effective method to determine stress distribution patterns for complex design.

A finite element study has focused on the interaction of craniofacial auricular implant with supporting temporal bone. A continuous mathematical model was developed for a craniofacial auricular implant. The model was subdivided into numerous discrete elements, which are then connected at nodal points. Linear equations are designed to relate the nodal forces to nodal displacements, and they are subsequently solved using a digital computer.

PRINCIPLES OF FINITE ELEMENT METHOD

Finite Element analysis solves a complex problem by redefining it as the summation of the solution of series of interrelated simple problems. The first step was to subdivide (i.e., discretize) the complex geometry into a suitable set of smaller "elements" of finite dimensions, which are assumed to be connected only at certain nodal points. These elements may be of a wide variety of shapes ranging from two dimensional structures to three dimensional bodies with curvilinear bodies. The finite element model when subjected to any kind of force or stress will undergo deformation with the displacement of individual nodes. This displacement was considered as the basic unknown and the stress strain and strain rates are further related to these stress.

The stiffness matrix (k) is used to relate the forces (f) and displacement at each node (u) of the structures via the equation,

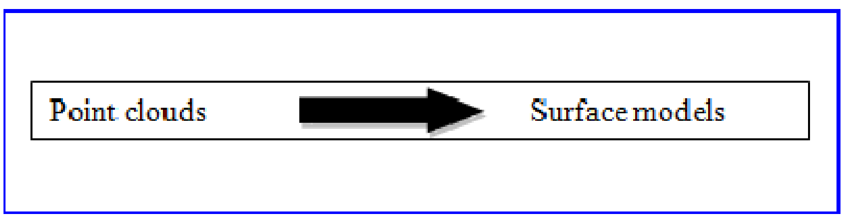
$\{F\} = [K] \{u\}$

Where {F} and {u} denote the summation of forces and displacements. This holds true for all linear static solutions i.e. in cases where the stress is directly proportional to strain. In cases with non linear behavior, the incremental method or the Newton-Raphson method can be used.

PROCEDURE: MODEL CREATION WITH REVERSE ENGINEERING: Reverse engineering is a process of capturing the geometry of existing physical objects and then using the data obtained as a foundation for new design.

1.3D cloud point generation

Temporal bone was scanned through 3D white light scanner as shown in **Figure 1**. Using Fiber white light and different size of fringe Patten the 3D cloud data was captured. The surface of the temporal bone texture was taken into thousand of point in 1 cm area. The file was saved in ASCII format for future development.



The point cloud data's obtained through the 3 D scanners can be converted into the surface models with the help of CAD/CAM/CAE tools.

2. Mesh generation:

ASCII file saved from the 3D white light machine was imported to CATIA software in Digitized shape editor workbench. By joining the million of 3D cloud data into the network forms the shape of the bone as shown in **Figure 2**. Each mesh shape was generated through 3 point to form triangle called facet body. Further this mesh model was saved in part file format.

3. <u>Surface generations</u>:

The saved file format of part file in the above section was again open in the CATIA software in quick surface reconstruction workbench, i.e. mesh file. By using quick surface generation tool the generated mesh data was converted into surface automatically as shown in **Figure-3.** Then the surface was copied and saved in separate file part format. Then the patch of each surface was joined through join tool. By using the exact boundary it generates the closed surface then saves the file.

4. <u>Solid generation:</u>

The closed surface was opened in the CATIA part workbench and by using the close surface tool was made to a solid mass as shown in **Figure- 4.** Then the file was saved in STP file format. The implant site selection was taken. The ideal placement was 18-20mm from the center of the external ear can opening and on the left-hand side between 1-2-0'clock positions for the most cranial implant and between the 3.30 and 4.30 positions for the caudal implant. The ideal placement on the right-hand side is between 10-11-0' clock position for the most cranial part and between the 7- 8-0' clock positions for the caudal implant as shown in **Figure- 5.**

5. <u>Optical Profilometer:</u>

Profilometer is a measuring instrument used to measure the surface's profile shown in **Figure - 6**. A vertical resolution was measured in nanometer level. It is similar to a phonograph that measures a surface as the surface is moved relative to the contact profilometer's stylus, this notion is changing along with the emergence of numerous non-contact profilometery techniques. By using non contact profilometer, the two craniofacial implant was scanned. It gives 1000 time projection. It was measured as V shape 60°and buttress shape 47°. By using the Pro/E wildfire 4.0 the modeled was assembled in location. And save the file in STP format.

In this study Craniofacial Auricular Implant models was simulated in three-dimensionally by Ansys 11.0 workbench. The influence of diameter and length of the craniofacial auricular implant on stress distribution was evaluated.

<u>ANALYSIS</u>

Design Verification by Product simulation and flow analysis:

In the Finite element analysis technique, the structure or component part to be analyzed was divided in to finite number of elements and the temperature. Nevertheless, there will be an *element of error* in such calculations, error limits acceptable in such large computations are already decided upon. Given the geometry of the mould, material, feed system dimensions and molding conditions, the program conducts a 3D analysis. Results are presented in a colour graphics format such that the engineer can actually watch the stress pattern develops.

<u>Geometric Data Of The Structure To Be Analyzed:</u> The implant was first observed for dimensions and structural formation through the optical comparator. The magnification was set to 10x for better observation. The thread shape profile was drawn by using the points that was obtained from the optical comparator. The thread shape profile was calculated, drawn and it is cutout from the original profile of the implant. The profile generated was saved as a drawing file (dwg) format. The 3D model of the implant was created in the Pro-e wildfire 4.0 software by giving various commands. This model was imported to the **ANSYS** software through **IGES** (initial graphic exchange specification) file for further analysis.

All the Six Craniofacial auricular implants of various dimensions mentioned above was observed through the optical comparator and was modeled and imported in the same way as described above.

FIGURE- 7 GROUP A: V –SHAPE THREAD DESIGN

SAMPLE- A-Craniofacial Auricular Implant model with diameter 3.75mm and length 3mm.

SAMPLE- B -Craniofacial Auricular Implant model with diameter 3.75 mm and length 4mm.

SAMPLE- C -Craniofacial Auricular Implant model with diameter 3.75 mm and length 6mm.

FIGURE- 8 GROUP II: BUTTRESS SHAPE THREAD DESIGN

SAMPLE-D- Craniofacial Auricular Implant model with diameter 3.75mm and length 3mm.

SAMPLE-E- Craniofacial Auricular Implant model with diameter 3.75mm and length 4mm.

SAMPLE-F- Craniofacial Auricular Implant model with diameter 3.75mm and length 6mm.

All the Six Craniofacial auricular implants of various dimensions mentioned above was observed through the optical comparator and was modeled and imported in the same way as described above.

MATERIAL PROPERTY OF CONSTITUENT MATERIALS

Finite element analysis assumes the following mechanical properties of the materials comprising the structure:

1) **Homogeneous**: mechanical properties of the material are the same throughout each structural element.
2) **Isotropic**: the material properties are the same in all direction of the structural element.
3) **Linearly elastic**: the deformations or strains of the structure are proportional to the applied forces

IMPLANT PROPERTIES:

The selected 3-D implant model represented commonly available Titanium Elastic modulus (e) = 1.03 x 10^5 M Pa, Poisson's ratio (u) = 0.35 Craniofacial Auricular Implant, Density of Implant 4.5 g/cm^3.

BONE PROPERTIES:

The entire volume of Temporal bone was considered to be a homogeneous, isotropic material with the character of Temporal bone [elastic modulus (e) 14000MPa, Poisson's ratio (u) = 0.3]. The interface between the implant and the Temporal bone was assumed to be an immovable junction. For this a "fixed contact" option in the software was chosen.

MATERIAL PROPERTIES

The assignment of proper material properties to a Finite element model was a necessary step. Stress-strain relationship in a structure was based on material properties. These are Young's Modulus (modulus of elasticity) and Poisson's Ratio. Material properties in the dental Finite Element analysis are mostly modeled as isotropic and homogenous.

Material name	Young's modulus in MPa	Poisson ration	Density g/cm^3
Temporal bone	14000	0.3	1500

LOADING OF THE CRANIOFACIAL AURICULAR IMPLANT MODEL: A three dimension model was done with forces of **10N** axial loading on the **Center of the implant** and **moment** on the same area of **100Nmm** was done.

Element type: The tetrahedral type of element was selected. The element size was 0.1mm. The models consisted of 59345elements and 101590 nodes as seen in **Figure-9**

Processing: In this step all the relevant information obtained in the pre-processing stage was put into a control data. This control data forms the basic unit to be analyzed. The finite element software now employs the inbuilt graphic facilities over the geometric data.

This geometric data was made into a mesh. Meshing is done by giving a meshing command to the software. Meshing divides the body into finite number of element with each element having nodes and control points. Loads are applied at the control points and displacement seen at the nodes.

THE BASIC STEP FOR CONDUCTING ARE:

Working steps in processing:-

1) Setting up of a control data.
2) The different layers of the body to be analyzed are represented as different areas.
3) Computer graphic facility of the finite element software is utilized and meshing is done of the different areas.

The meshing divides the whole geometric body and its layers into finite elements and this was then subjected to analysis.

The ANSYS 11.0 software computer program is employed to generate input data for the finite element stress analysis. All geometric and elastic parameters of all components are entered into the computer program. The data included (1) total number of nodal points (2) total number of elements (3) the numbering system identifying each element (4) young's modulus and poisson's ratio of each element (5) the numbering system identifying each nodal point (6) the coordinates of each nodal point (7) the type of boundary constraints and (8) the evaluation of the forces at the external nodes.

From the previously modeled implant and bone models the x, y, and z coordinates was determined. When these x, y, and z coordinates were input into the ANSYS 11.0 FEM software program the periphery of these of the cross section of Craniofacial auricular implant and temporal bone was plotted on the computer screen. After all these coordinates were united appropriately the implant and bone were appreciated as different layers. Each of these layers was designated as different areas shown in**Figure-10.**

The finite element software in which the model was created meshes the different areas independently. Thus the whole Craniofacial auricular implant and temporal bone model was divided into different nodes and elements as shown in **Figure- 11.** .he model thus created was given life like properties by inducing into the different layers their respective modulus of elasticity and poisson's ratio.

Modulus of elasticity = stress / strain

Poisson's ratio = lateral strain / longitudinal strain

Stress = force / unit area

Strain = change in length / original length

These properties when induced in the respective areas of the model can predict the behavior and stress propagation of the material under testing when a load was given to it.

Loading the prepared model:

A three dimension model was done with forces of **10N** axial loading on the **Center of the implant** and **moment** on the same area of **100Nmm** was done. The load applied to the Craniofacial auricular implant was static type of loading as shown in **Figure-12.** The result thus obtained was taken up for interpretation. The model showed propagation of stresses both numerically and by color coding as shown in **Figure13- 18.**

A force of **10N** axial loading on the **Center of the gold casting bar connecting two craniofacial auricular implant** and **moment** on the same area of **100Nmm** was also analyzed with static type of loading as shown in **Figure-19and 20.**

The model showed propagation of stresses both numerically and by color coding.

Post Processing:

Once control data is subjected to analysis by the Finite element method (FEM) software, the result was interpreted. This step consisted of the post processing stage. Maximum principal Stress distribution in the Finite element model comes in numerical values and in color coding as shown in **Figure-21 and 22**.

Maximum value of Principal stress = is denoted **by red color**

Minimum value of Principal stress = is denoted by **blue color**

The in-between values are represented by bluish green, green, greenish yellow and yellowish red in the ascending order of stress distribution.

Working steps in post processing consists of:

1) Analysis

2) Interpretation of results both numerically and by color- coding

The Principal stress (MPa) at the Craniofacial auricular implant – Temporal bone interface was computed using Finite element Analysis (FEA) software.

Two case studies was done:

1. **Without gold casting bar**
2. **With gold casting bar- as shown in 23-28.**

All computations was performed on all 3-Dimensions method. Craniofacial auricular implant models mentioned above and the value of Maximum Principal Stress on the implant and the temporal bone was obtained. All the values of principal stress on the craniofacial auricular implant and the temporal bone obtained during this study was tabulated and analyzed for computation of the results.

METHODOLOGY FOR RESONANCE FREQUENCY ANALYSIS

Male adult fresh goat maxilla was included in this study. A total of 10 craniofacial auricular implant sites was selected for the placement of craniofacial auricular implant in the goat maxilla. V-shape thread design and Buttress- shape thread design was chosen and placement done at five different sites named as 1, 2, 3, 4 and 5 respectively.

Primary stability at the time of implant placement is measured using Resonance frequency analysis. It is the stability at the time of implant placement which is related to the level of primary bone contact. The level of bone contact with implant is affected by many factors such as thread design, surgical procedure and bone quality.

This study was made to experimental findings to demonstrate that resonance frequency is related to implant stability in the surrounding tissues, which means a higher bone-to implant contact percentage.

The purpose of this study was to compare the initial stability in V-shape thread design and Buttress shape thread design with length of 3mm and diameter of 3.75mm. By measuring the Implant stability quotient, the reading was noted and was experimented.

PROCEDURE FOR THE STUDY PRIMARY STABILITY IN THE FRESH MAXILLA OF THE GOAT BY RESONANCE FREQUENCY ANALYSIS METHOD

Materials:

1. Osstell mentor (Integration Diagnostics, Gamlestadsv.3B, Sweden
2. Fresh goat maxilla
3. Craniofacial auricular implant-

   A, V-Shape thread design

   B, Buttress shape thread design
4. Smart peg -Magnetic transducer

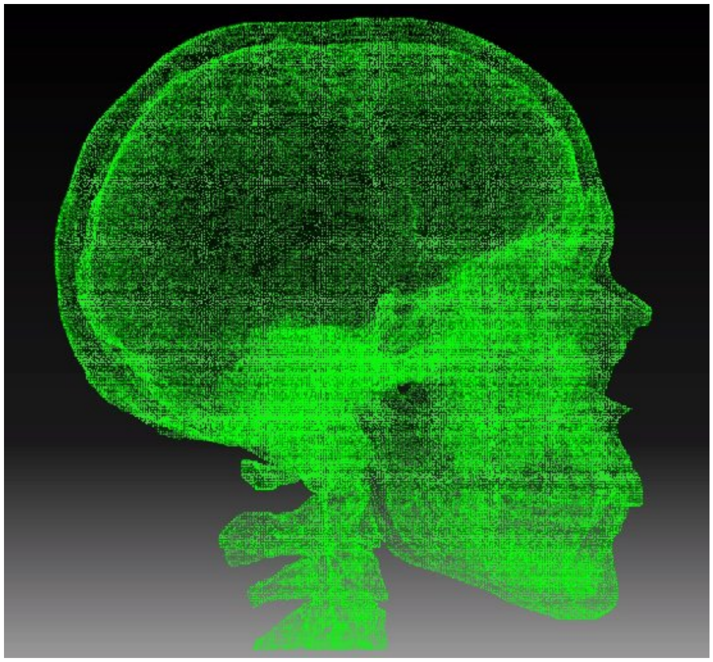
It is a measuring device to measure the stability of implant. The primary stability was measured with ISQ values using Osstell mentor at the time of placement.

The RFA device (smart peg; Integration Diagnostic AB., Gemlestadsvagen, Sweden **Figure-1**) was placed by hand tightening with the ratchet made ingeniously. ISQ values was measured parallel and perpendicular to the bone as seen in **Figure- 2** ISQ values for each fixture were taken as the mean of ISQ values which was taken in two orientations as seen in **Figure- 3**. Measurement was taken with a transducer screwed on to the implant the piezo element of which are caused to oscillate. The device records the resonance frequency arising from the implant bone interface. This was displaced graphically. The oscillation of the implant –transducer element is recorded as the Implant Stability Quotient. The Implant stability quotient value for both the V- shape thread design and Buttress- shape thread design are taken and evaluated.

PHOTOGRAPHS

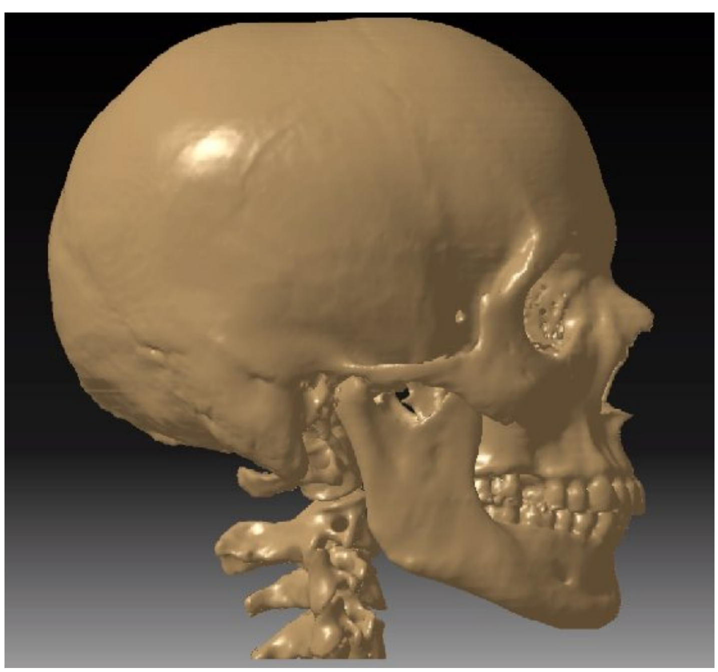
3D CLOUD GENERATION OF SKULL BY USING 3D WHITE LIGHT SCANNER

FIGURE-1



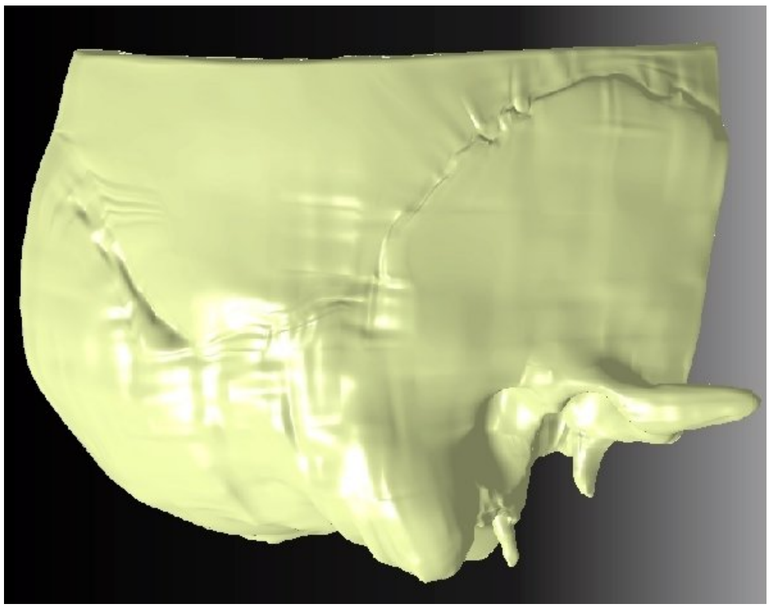
mESH GENERATION FROM THE 3D CLOUD POINT BY USING catia SOFTWARE

FIGURE-2



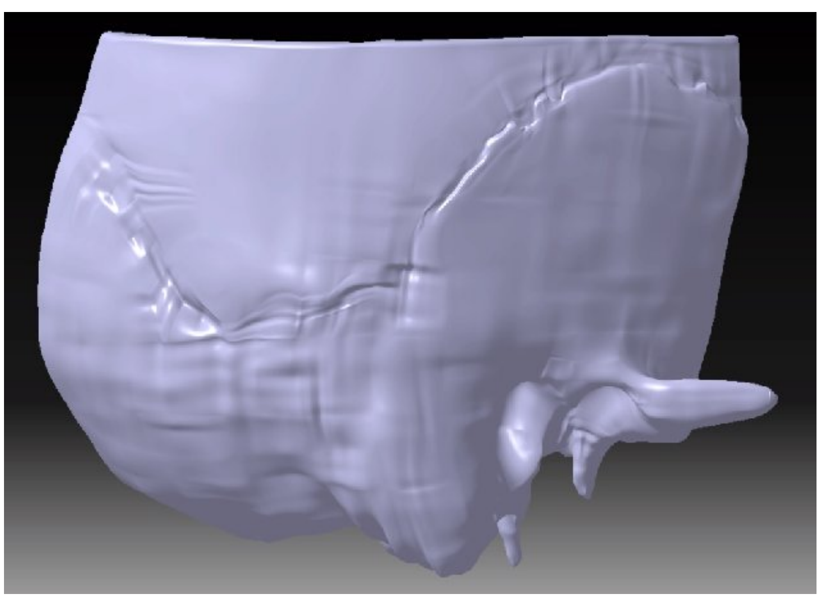
SURFACE GENERATION OF TEMPORAL BONE FROM MESH BY USING CATIA SOFTWARE

FIGURE-3



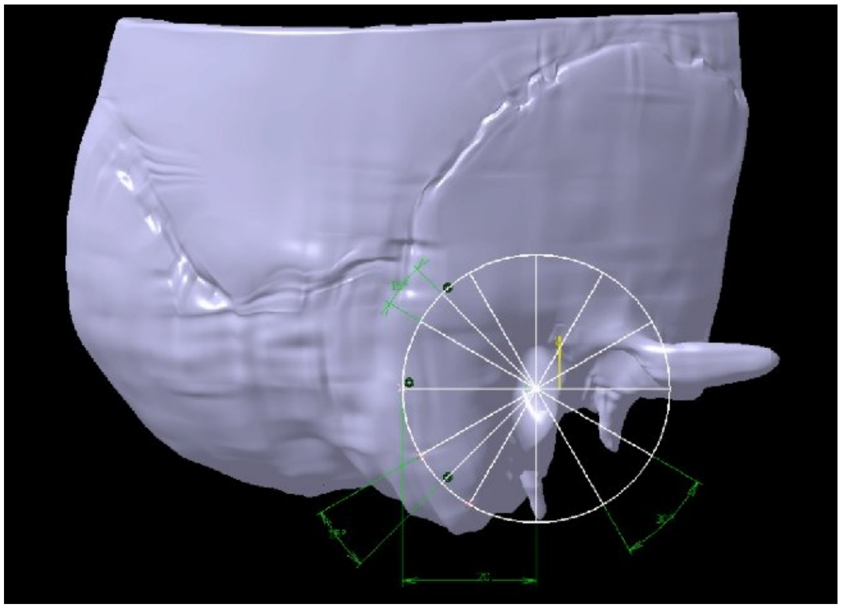
SOLID GENERATION OF TEMPORAL BONE FROM SURFACE BY USING CATIA SOFTWARE

FIGURE-4



POSITION OF THE TEMPORAL SITE FOR THE PLACEMENT OF CRANIOFACIAL AURICULAR IMPLANT USING CATIA SOTWARE

FIGURE -5

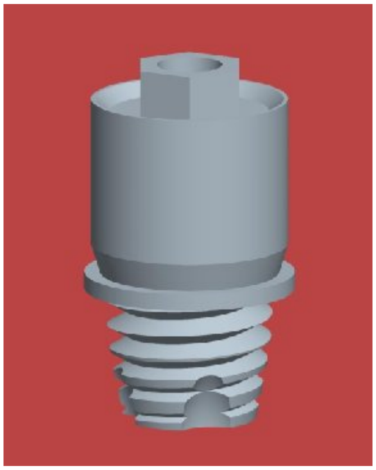


OPTICAL COMPARATOR

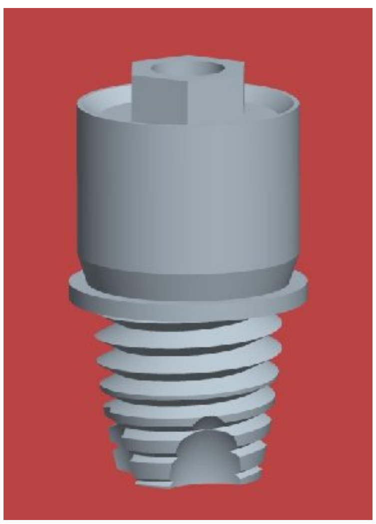
FIGURE - 6

FIGURE- 7

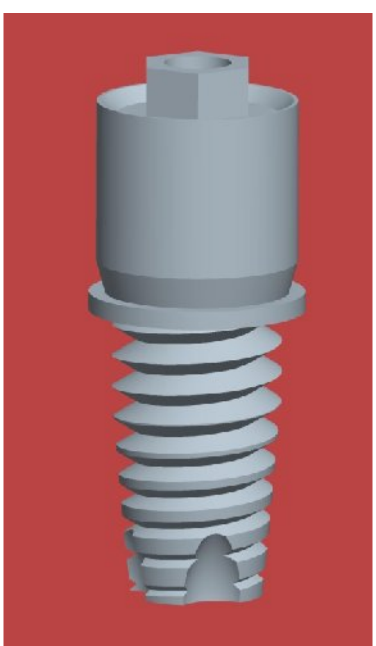
V- SHAPE THREAD DESIGN



CRANIOFACIAL AURICULAR IMPLANT
SAMPLE-A DIAMETER 3.75MM, LENGTH-3MM



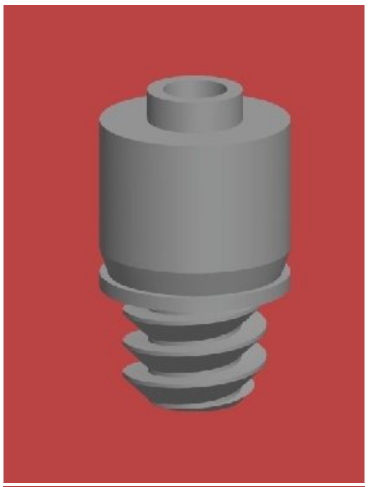
CRANIOFACIAL AURICULAR IMPLANT
SAMPLE-B- DIAMETER 3.75MM, LENGTH-4MM



CRANIOFACIAL AURICULAR IMPLANT
SAMPLE-C- DIAMETER 3.75MM, LENGTH-6MM

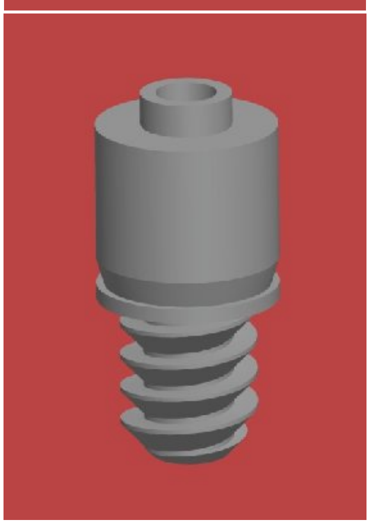
FIGURE- 8

BUTTRESS- SHAPE THREAD DESIGN



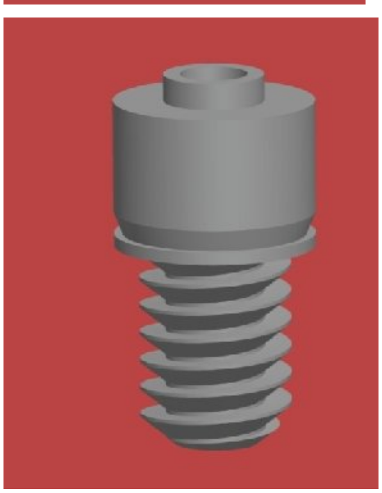
CRANIOFACIAL AURICULAR IMPLANT
SAMPLE-D DIAMETER 3.75MM, LENGTH-

3MM



CRANIOFACIAL AURICULAR IMPLANT
SAMPLE-E- DIAMETER 3.75MM, LENGTH-

4MM

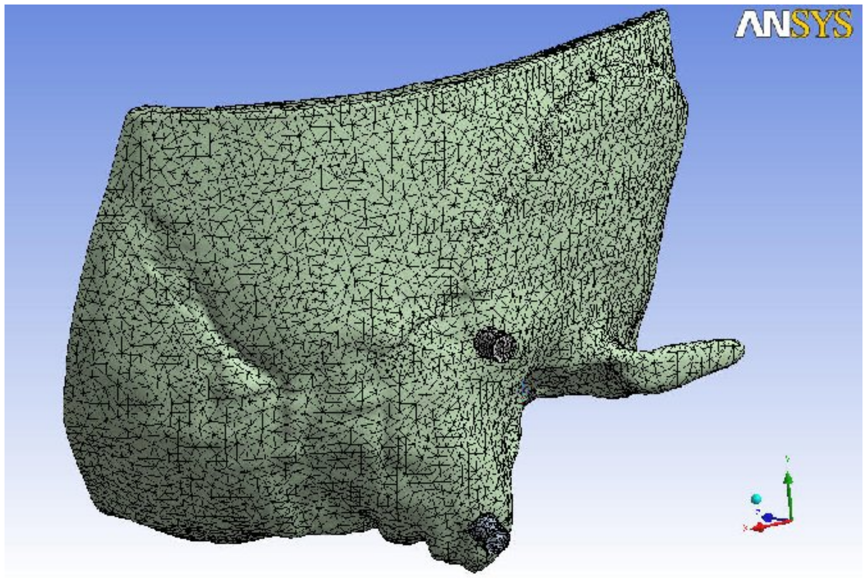


CRANIOFACIAL AURICULAR IMPLANT
SAMPLE-F- DIAMETER 3.75MM, LENGTH-

6MM

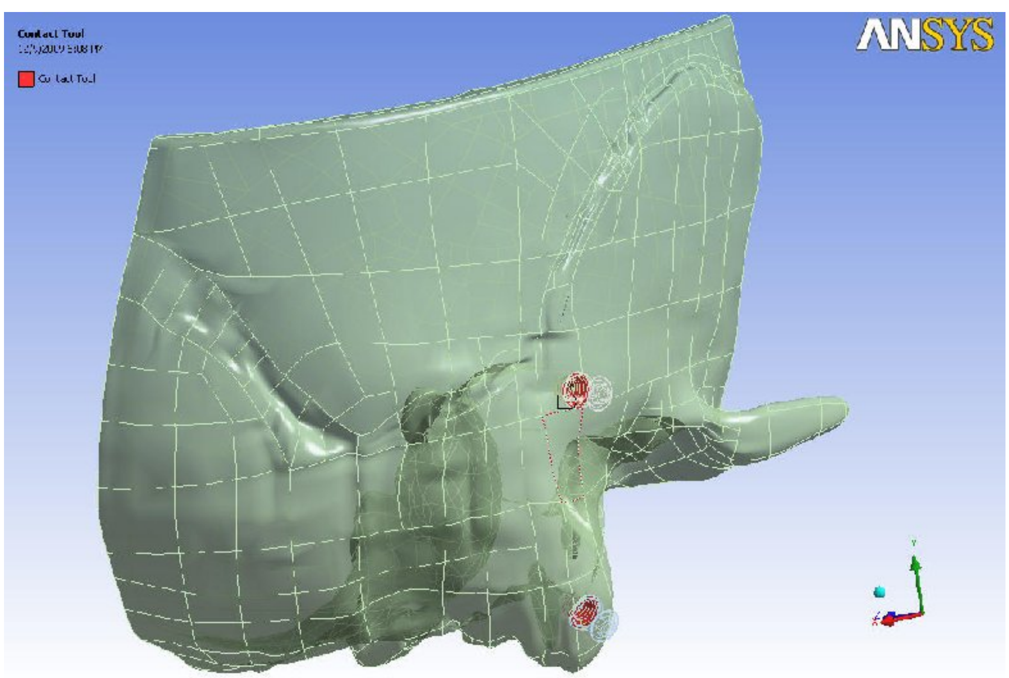
FINITE ELEMENT MODEL OF CRANIOFACIAL AURICULAR IMPLANT WITH TEMPORAL BONE CONTAINING NODES AND ELEMENTS USING ANSYS SOTWARE

FIGURE - 9

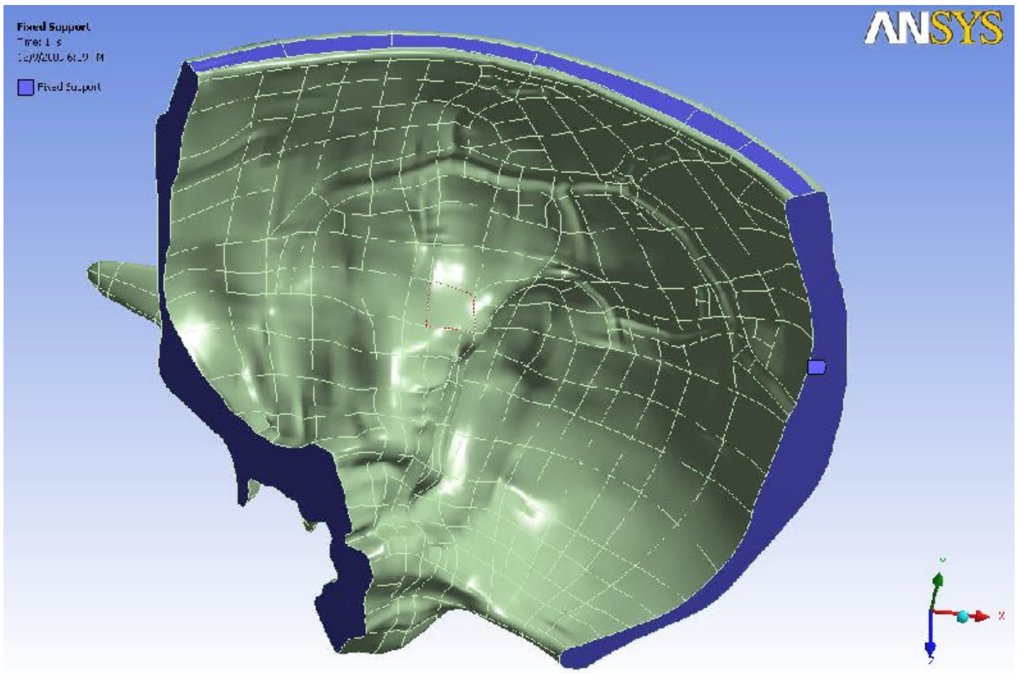


CONTACT BODY OF CRANIOFACIAL AURICULAR IMPLANT WITH TEMPORAL BONE

FIGURE- 10

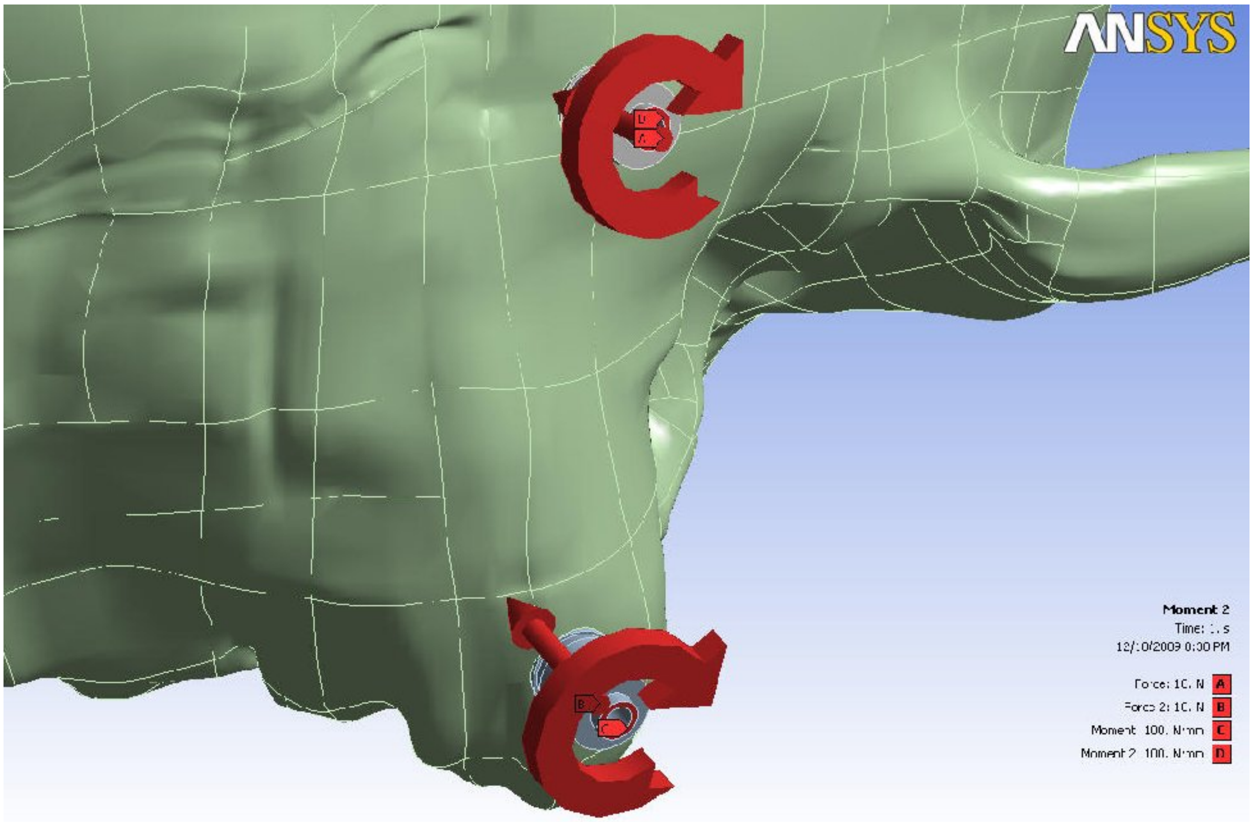


TEMPORAL BONE MODEL MADE AS A FIXED SUPPORT FOR ANALYSIS FIGURE- 11



AXIAL LOAD WITH MOMENT APPLIED ON CENTER OF THE CRANIOFACIAL AURICULAR IMPLANT

FIGURE- 12



A indicates force acting in axial direction on cranial part of auricular implant = 10N

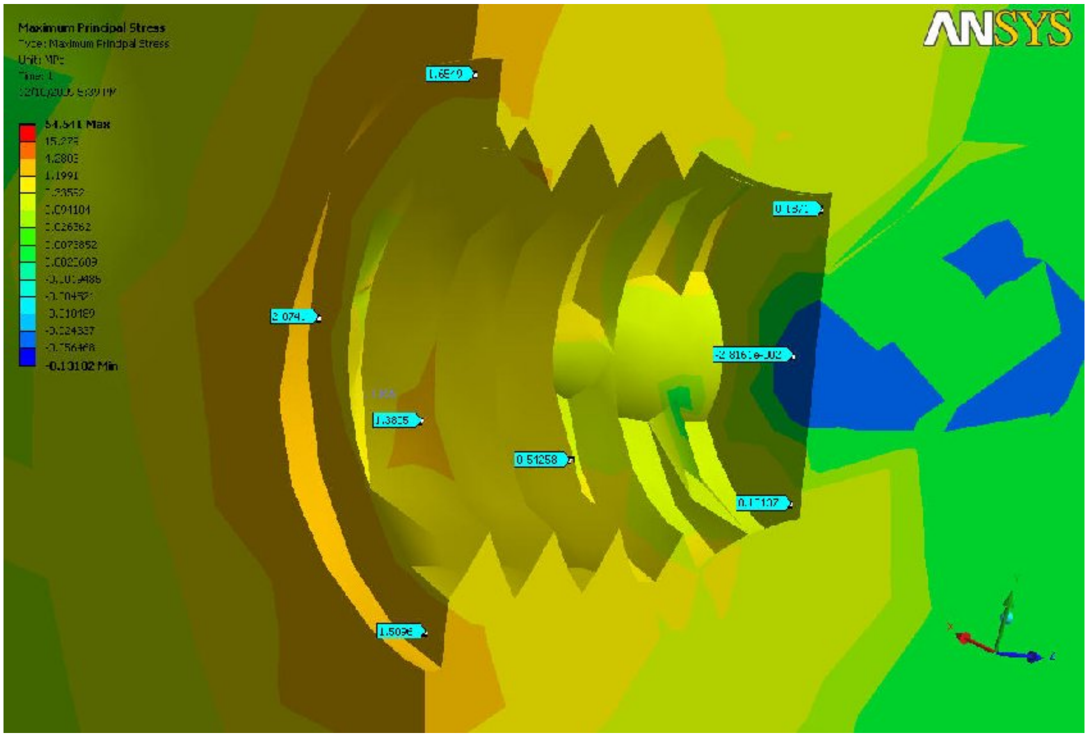
B indicates force acting in axial direction on caudal part of auricular implant = 10N

C indicates moment acting in on caudal part of auricular implant = 100Nmm

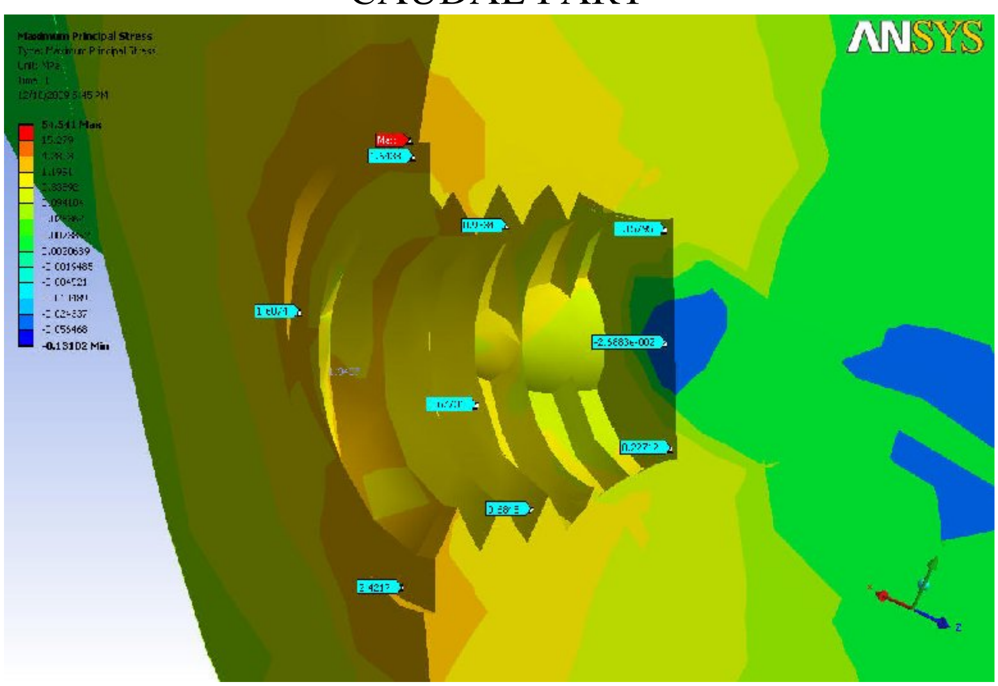
D indicates moment acting in on cranial part of auricular implant = 100Nm

PRINCIPAL STRESS DEVELOPED ON TEMPORAL BONE AFTER ANALYSING IN SAMPLE A DIAMETER 3.75MM, LENGTH-3MM

FIGURE- 13- CRANIAL PART



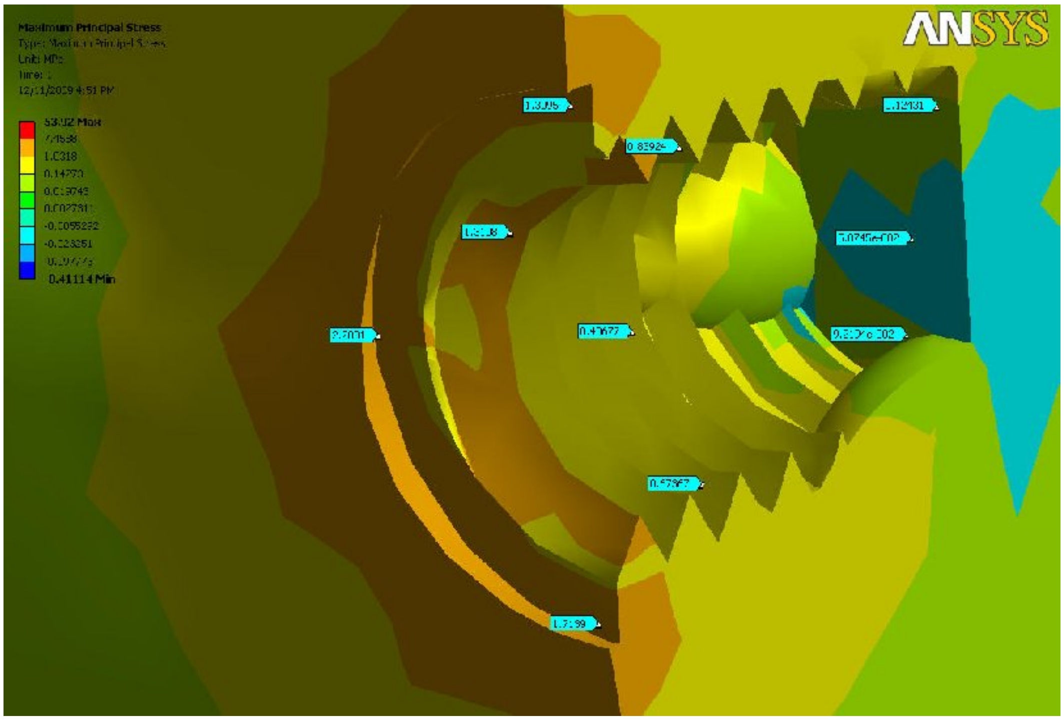
CAUDAL PART



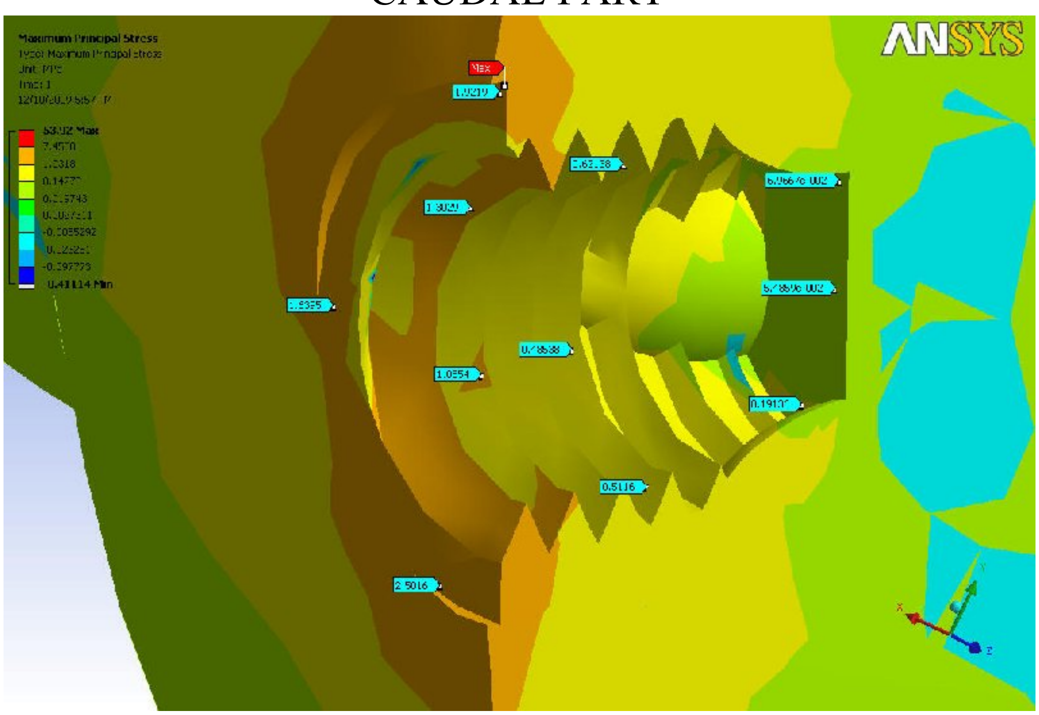
CAUDAL PAR

PRINCIPAL STRESS DEVELOPED ON TEMPORAL BONE AFTER ANALYSING IN SAMPLE B DIAMETER 3.75MM, LENGTH-4MM

FIGURE-14 -CRANIAL PART

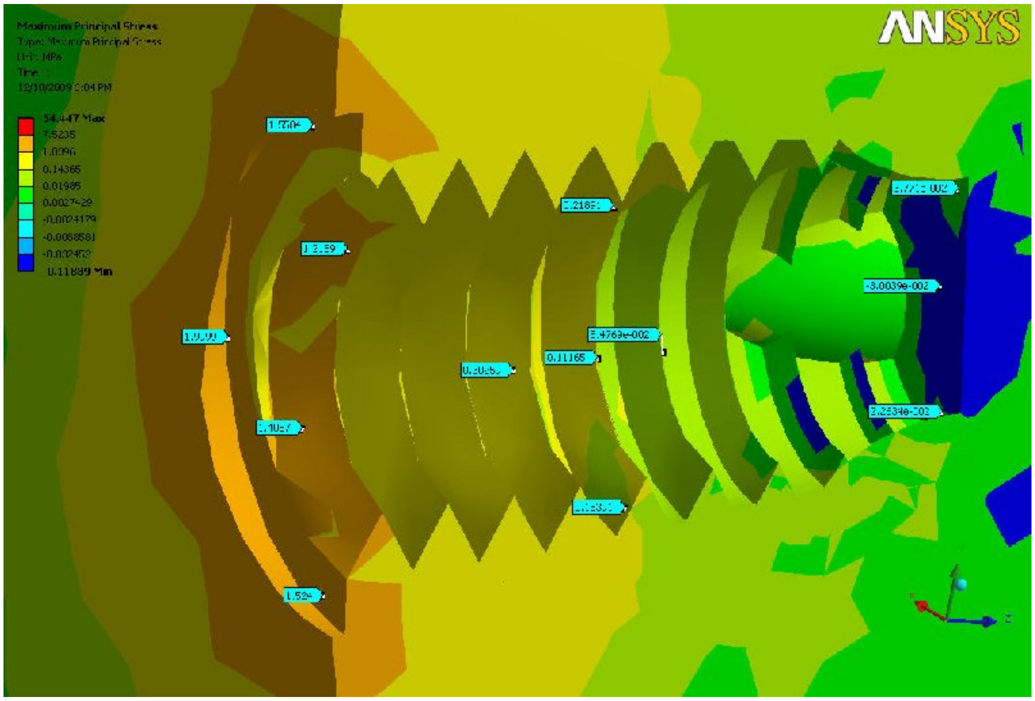


CAUDAL PART

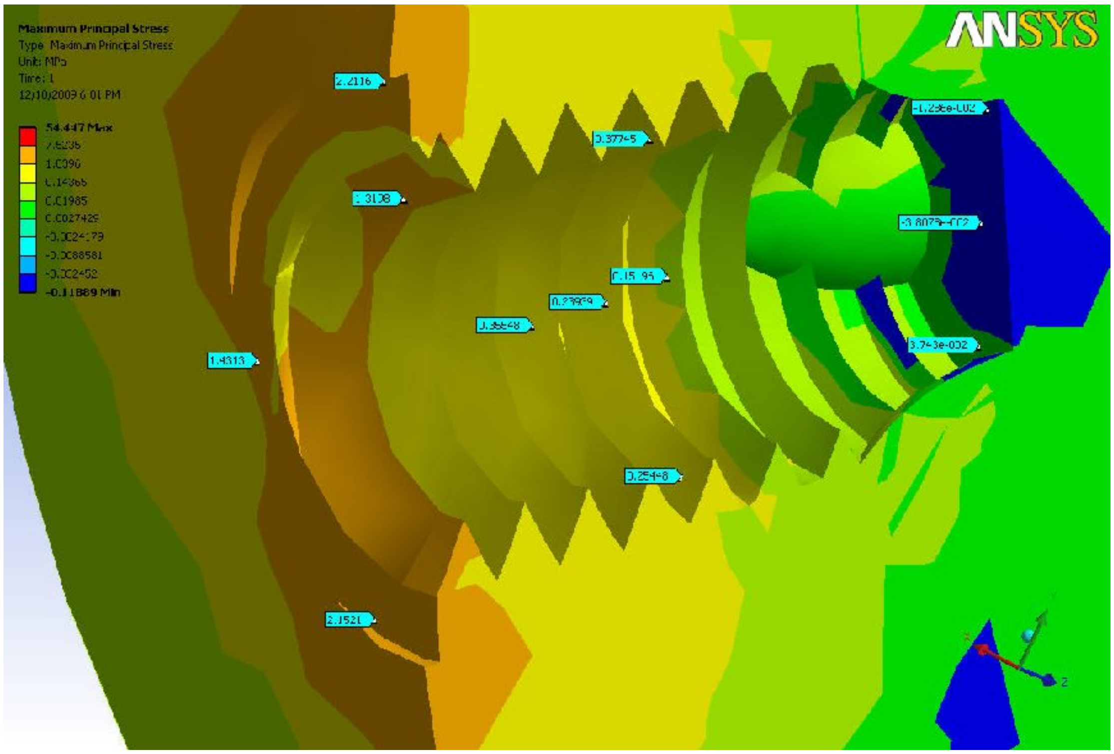


PRINCIPAL STRESS DEVELOPED ON TEMPORAL BONE AFTER ANALYSING IN SAMPLE C DIAMETER 3.75MM, LENGTH-6MM

FIGURE- 15- CRANIAL PART

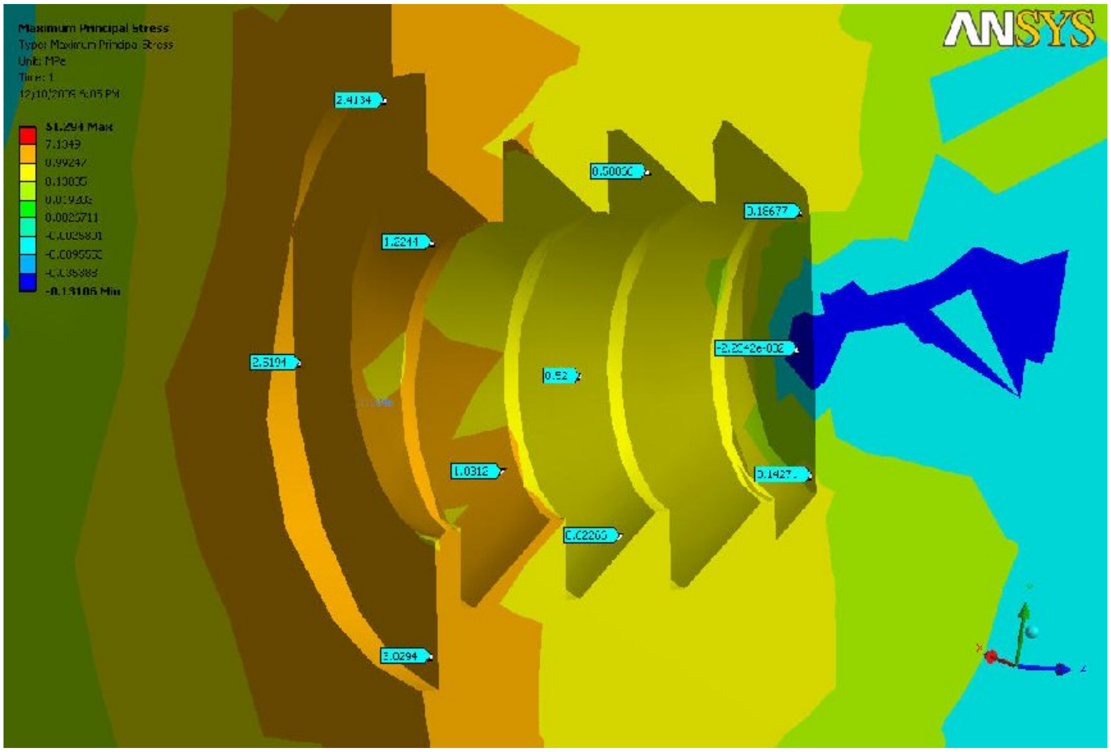


CAUDAL PART

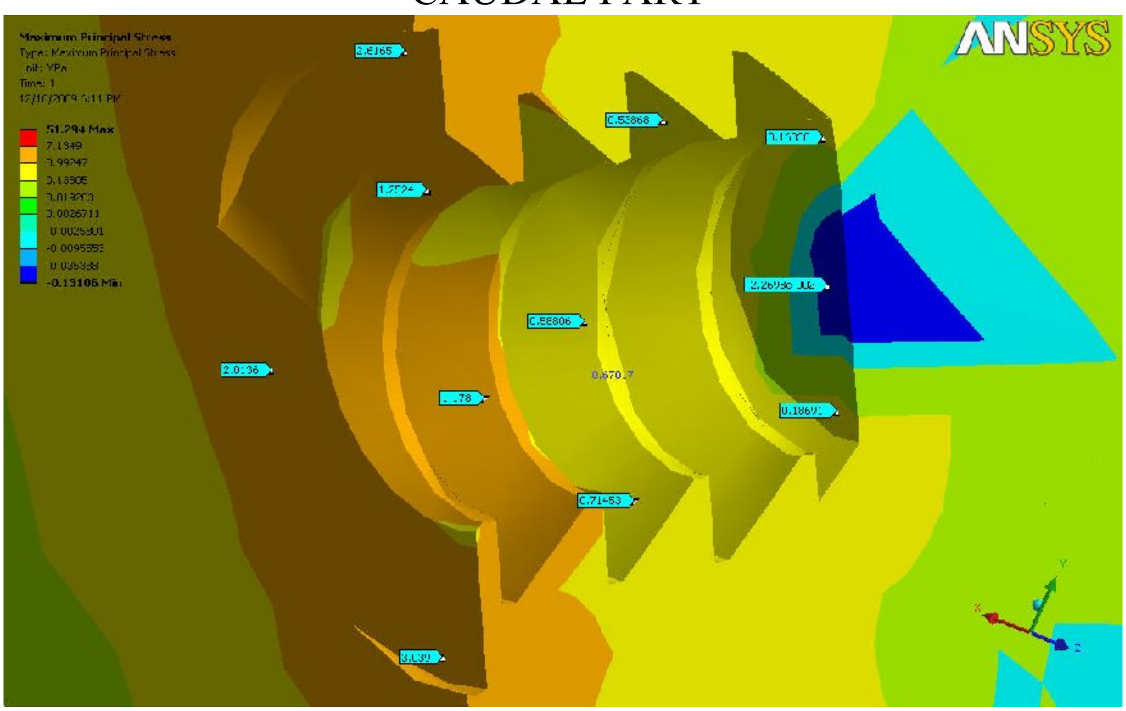


PRINCIPAL STRESS DEVELOPED ON TEMPORAL BONE AFTER ANALYSING IN SAMPLE D DIAMETER 3.75MM, LENGTH-3MM

FIGURE- 16- CRANIAL PART

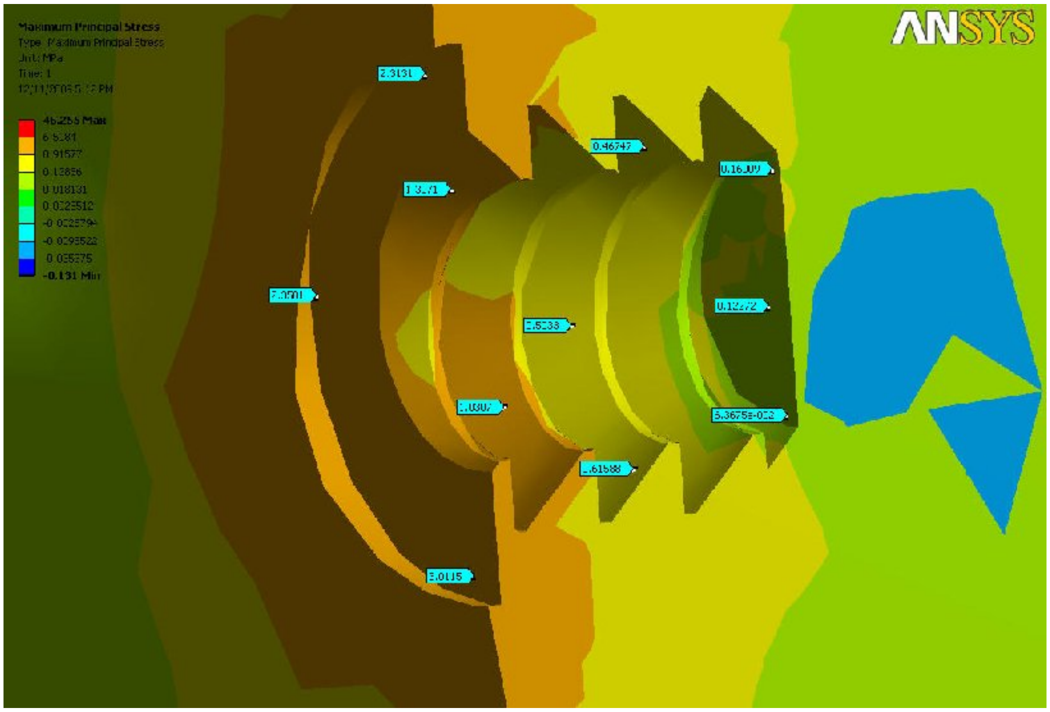


CAUDAL PART

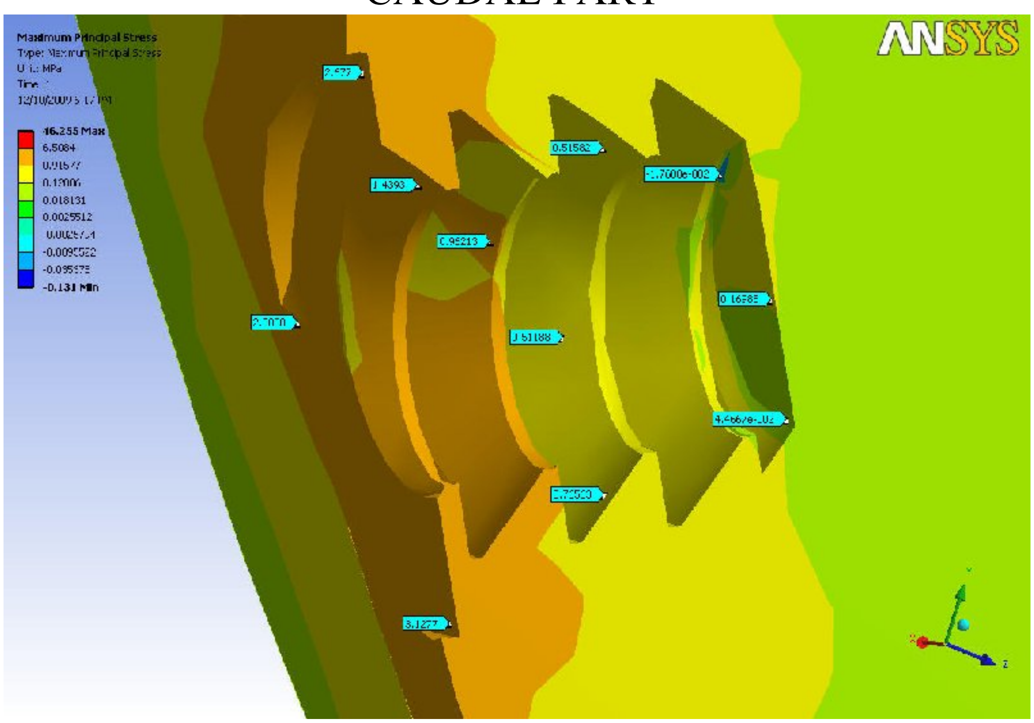


PRINCIPAL STRESS DEVELOPED ON TEMPORAL BONE AFTER ANALYSING IN SAMPLE E DIAMETER 3.75MM, LENGTH-4MM

FIGURE- 17 -CRANIAL PART

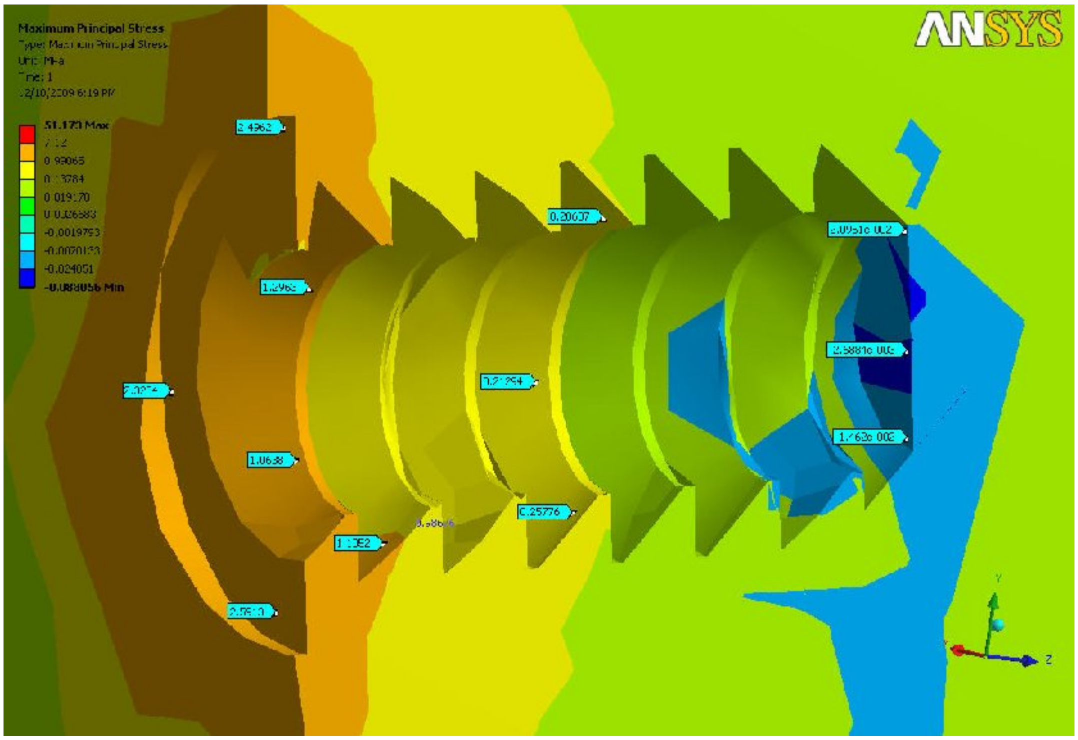


CAUDAL PART



PRINCIPAL STRESS DEVELOPED ON TEMPORAL BONE AFTER ANALYSING IN SAMPLE F DIAMETER 3.75MM, LENGTH-6MM

FIGURE- 18- CRANIAL PART



CAUDAL PART

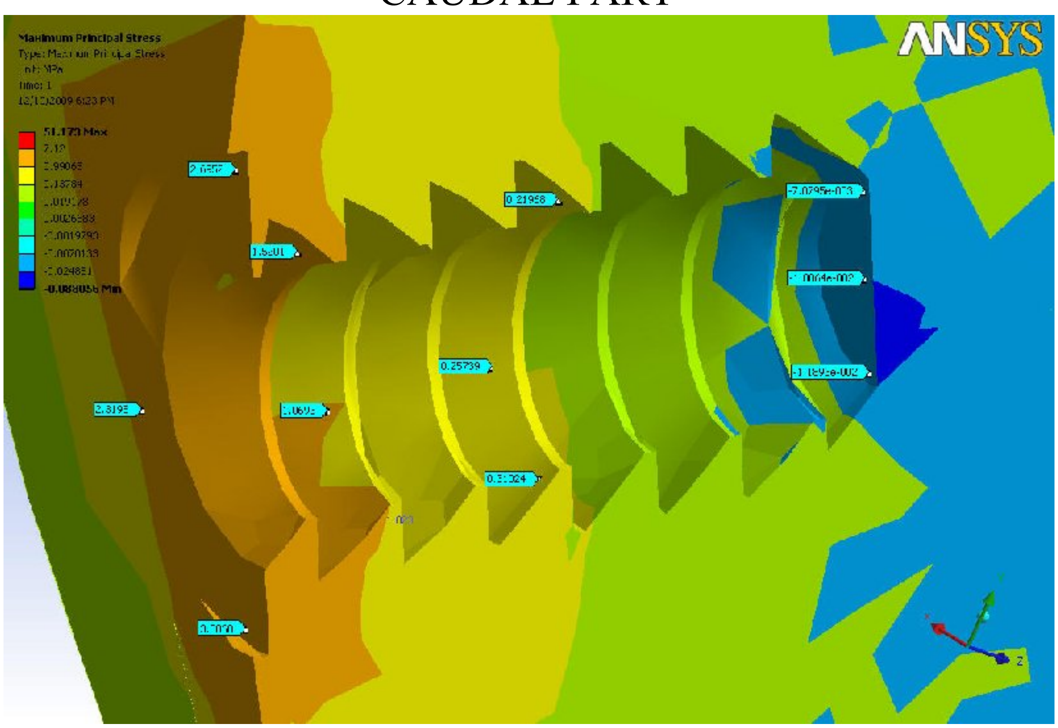


FIGURE- 19 -FINITE ELEMENT MODEL OF CRANIOFACIAL AURICULAR IMPLANT WITH GOLD ALLOY CASTING BAR CONTAINING NODES AND ELEMENTS USING ANSYS SOTWARE

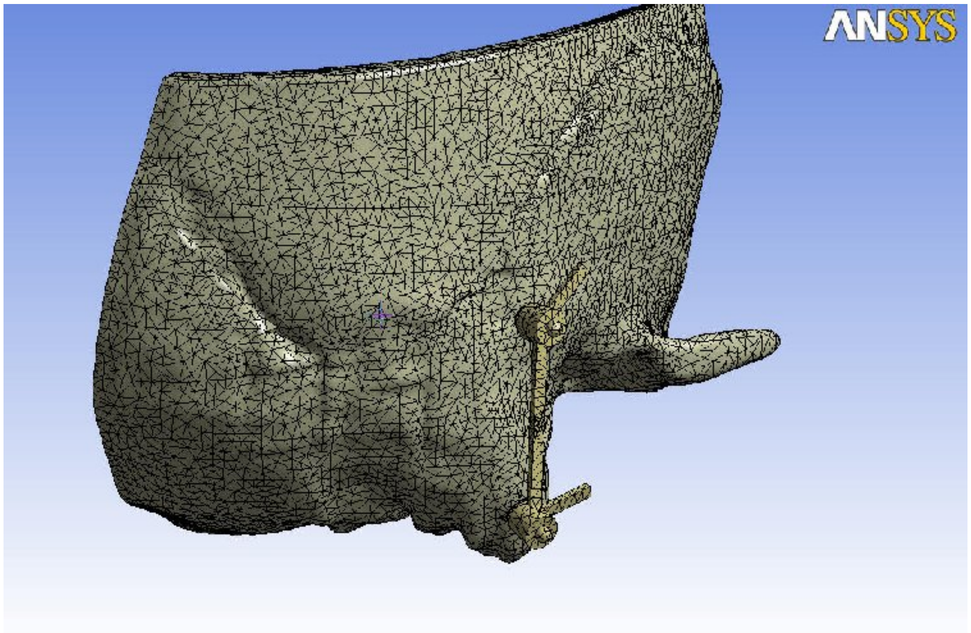


FIGURE -20 - AXIAL LOAD APPLIED ON CENTER OF THE GOLD ALLOY CASTING BAR FIGURE

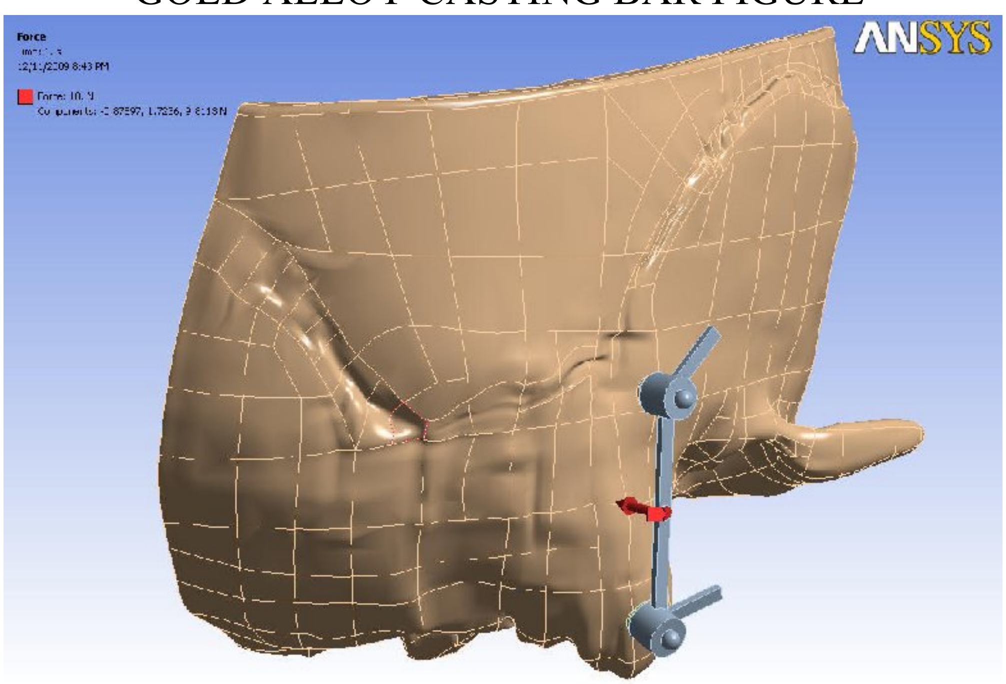


FIGURE- 21 -MAXIMUM PRINCIPLE STRESS ACTING ON THE GOLD ALLOY CASTING BAR

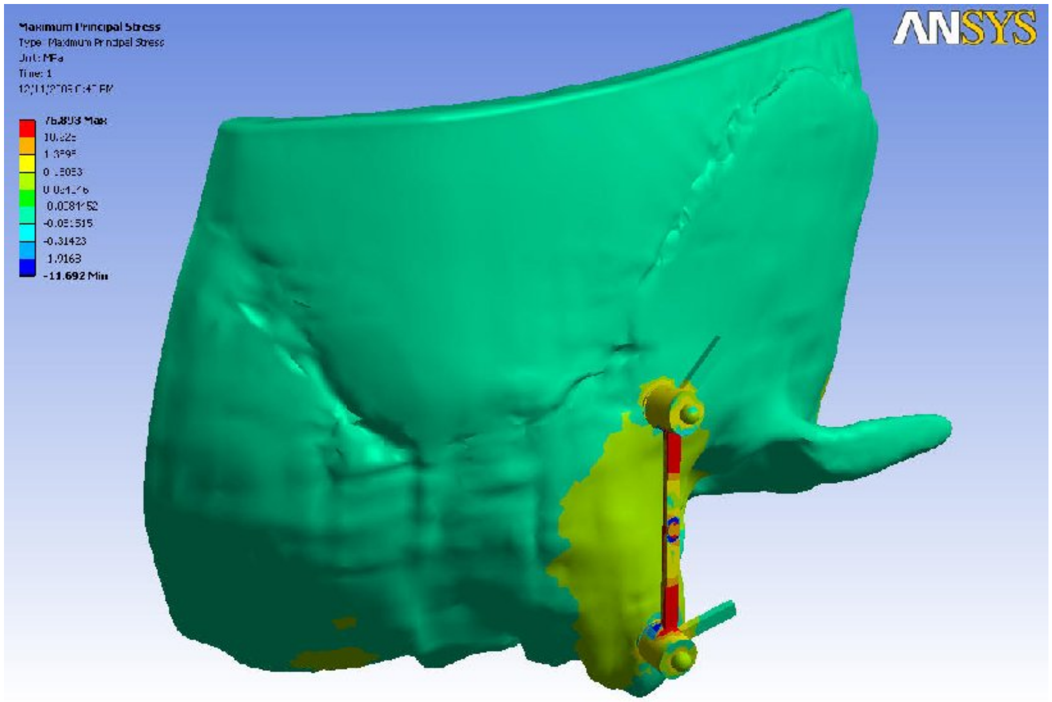
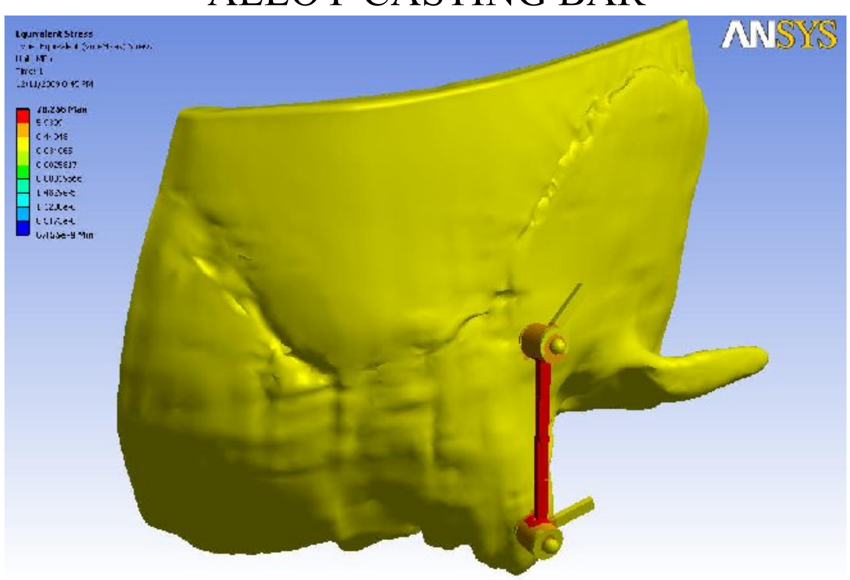
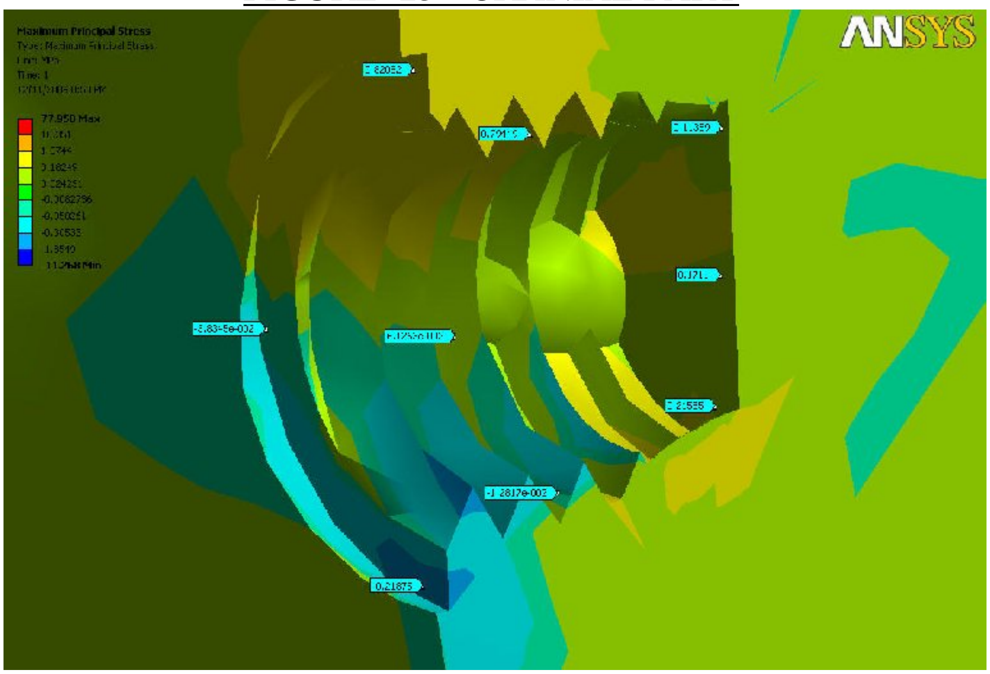


FIGURE -22 -EQUIVALENT STRESS ACTING ON THE GOLD ALLOY CASTING BAR

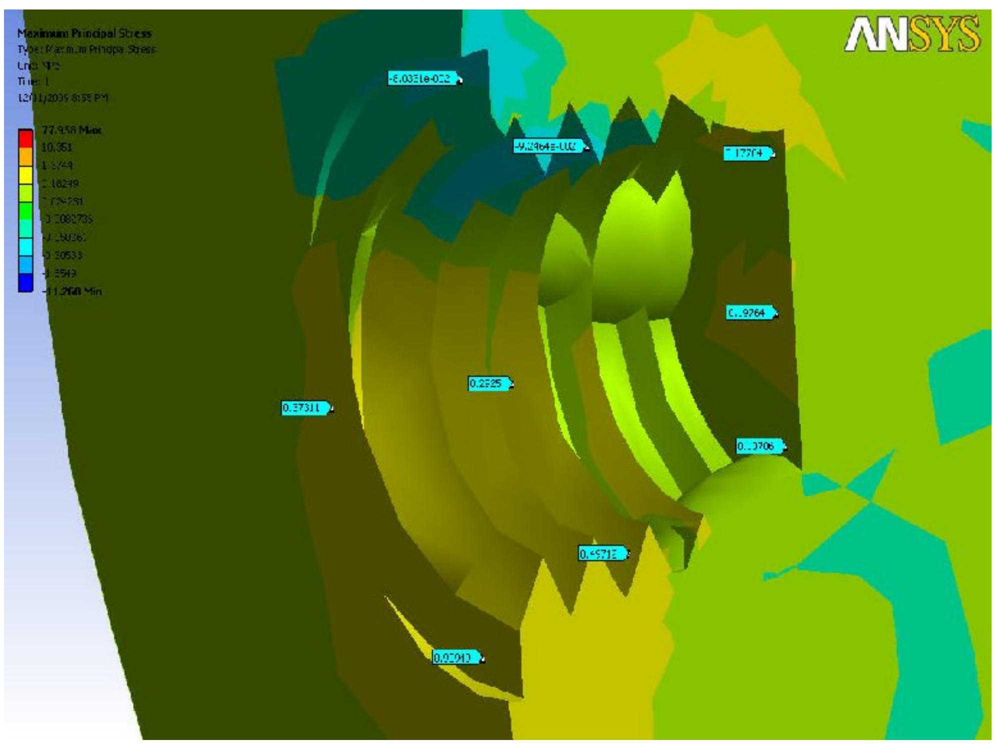


PRINCIPAL STRESS DEVELOPED ON TEMPORAL BONE AFTER ANALYSING SAMPLE G GOLD ALLOY CASTING BAR 3.75MM, LENGTH 3MM

FIGURE- 23 - CRANIAL PART

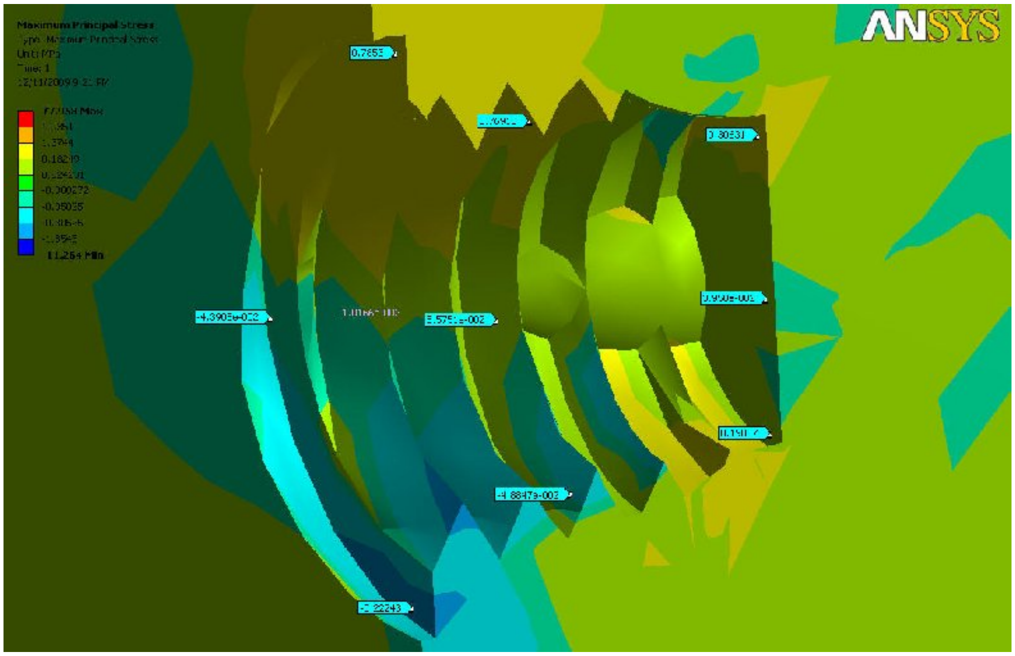


CAUDAL PART

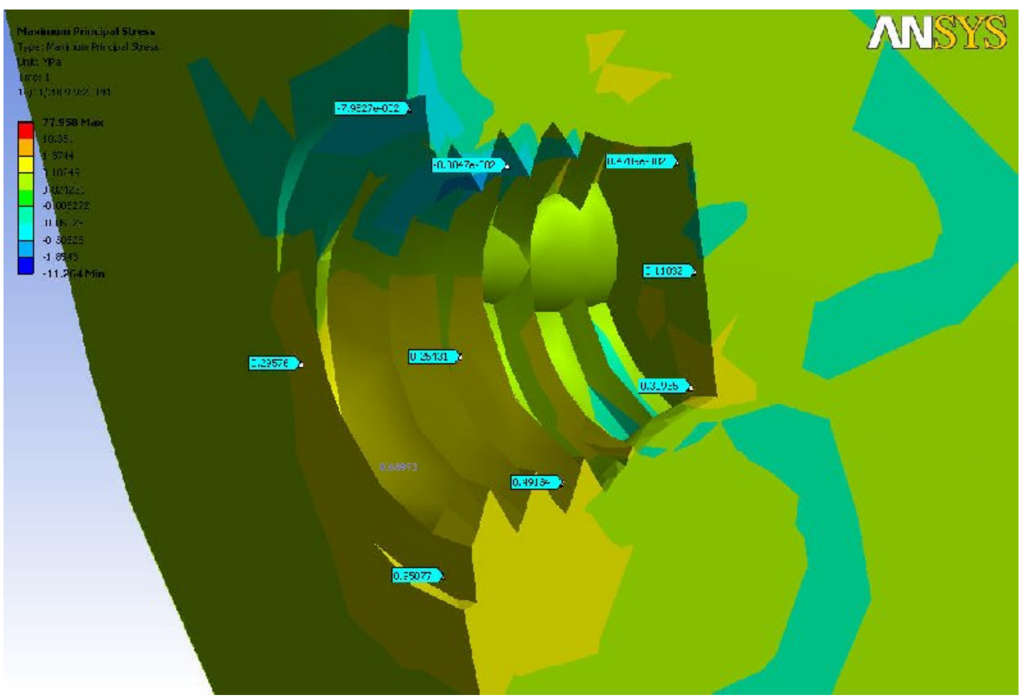


PRINCIPAL STRESS DEVELOPED ON TEMPORAL BONE AFTER ANALYSING IN SAMPLE H DIAMETER 3.75MM, LENGTH-4MM

<u>FIGURE- 24 - CRANIAL PART</u>

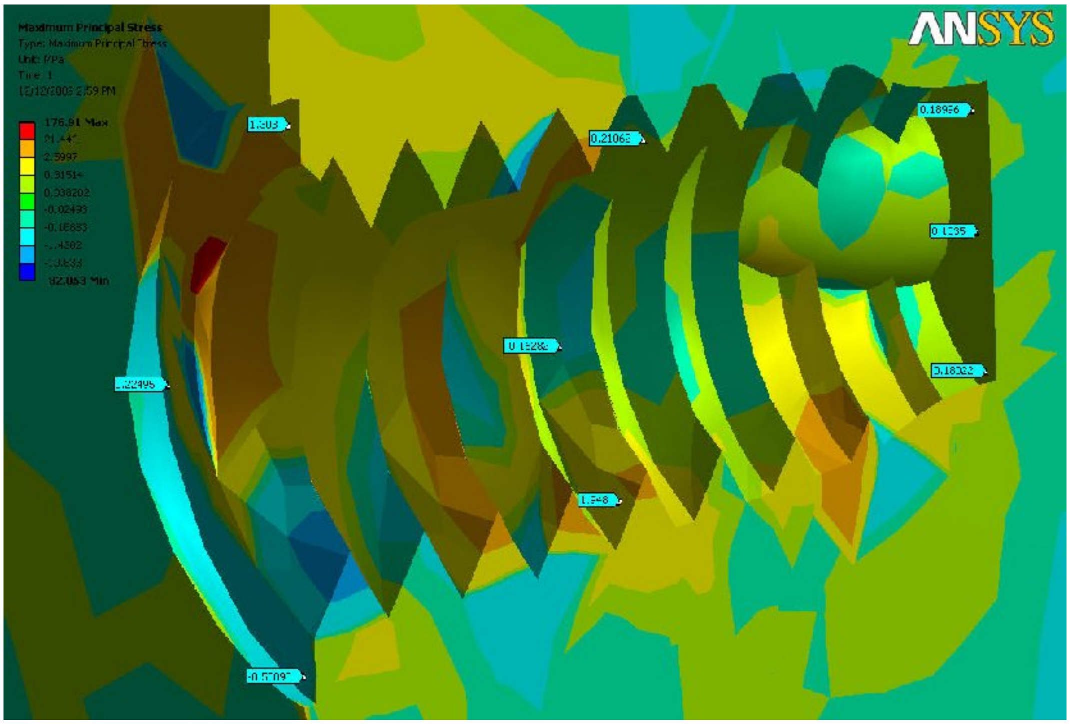


CAUDAL PART

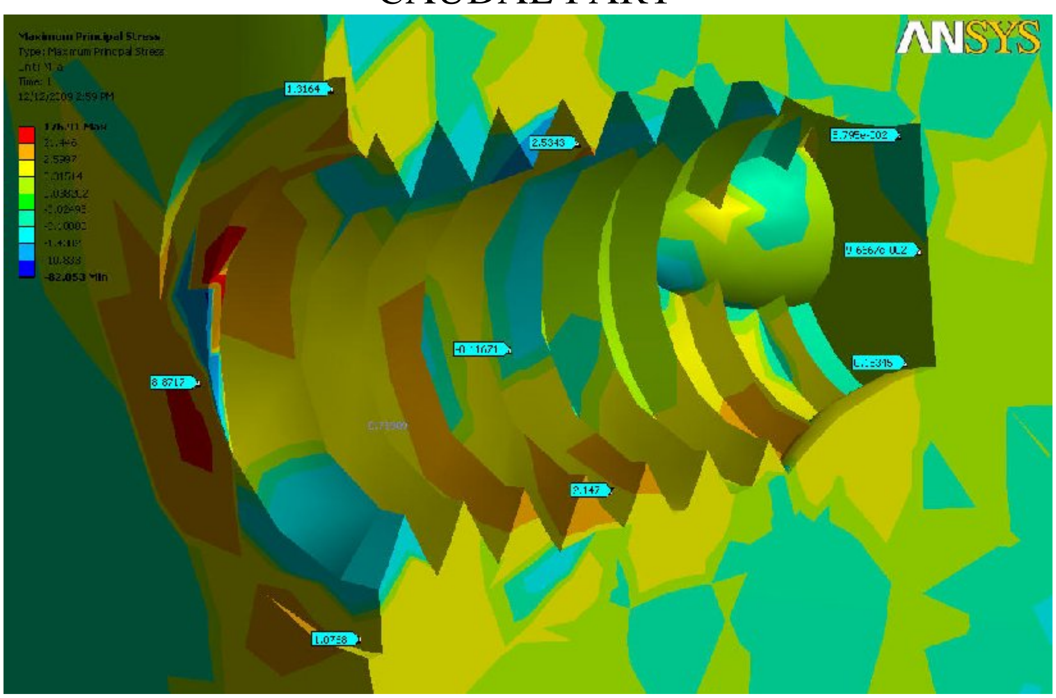


PRINCIPAL STRESS DEVELOPED ON TEMPORAL BONE AFTER ANALYSING IN SAMPLE I DIAMETER 3.75MM, LENGTH-6MM

FIGURE- 25- CRANIAL PART

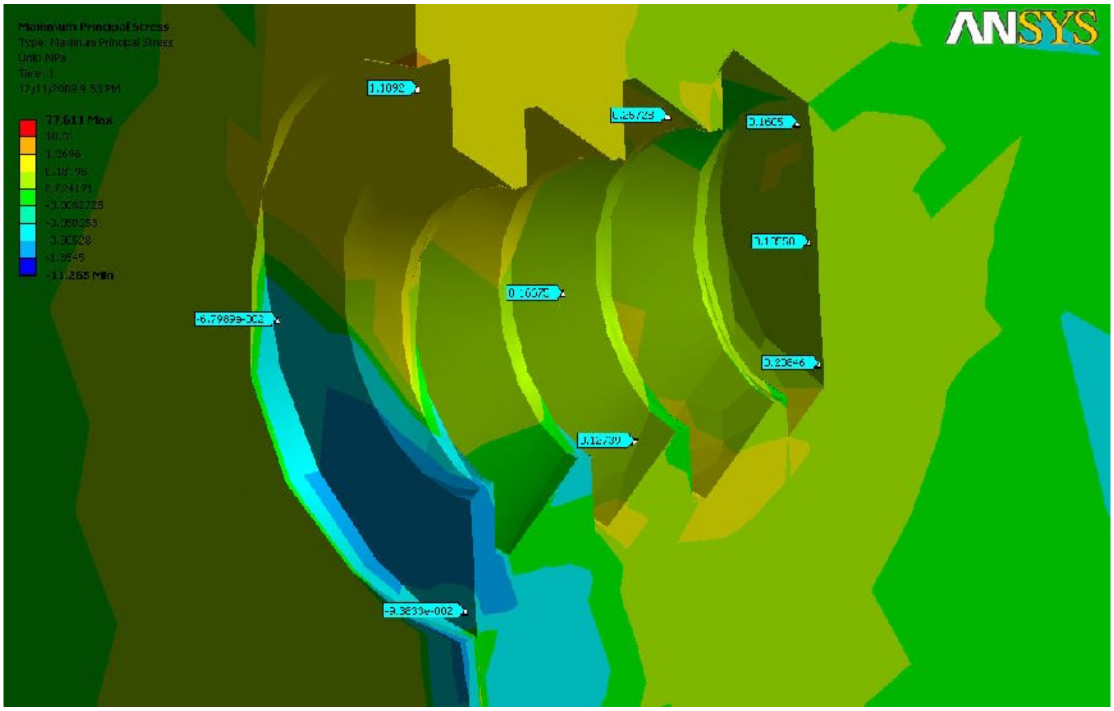


CAUDAL PART

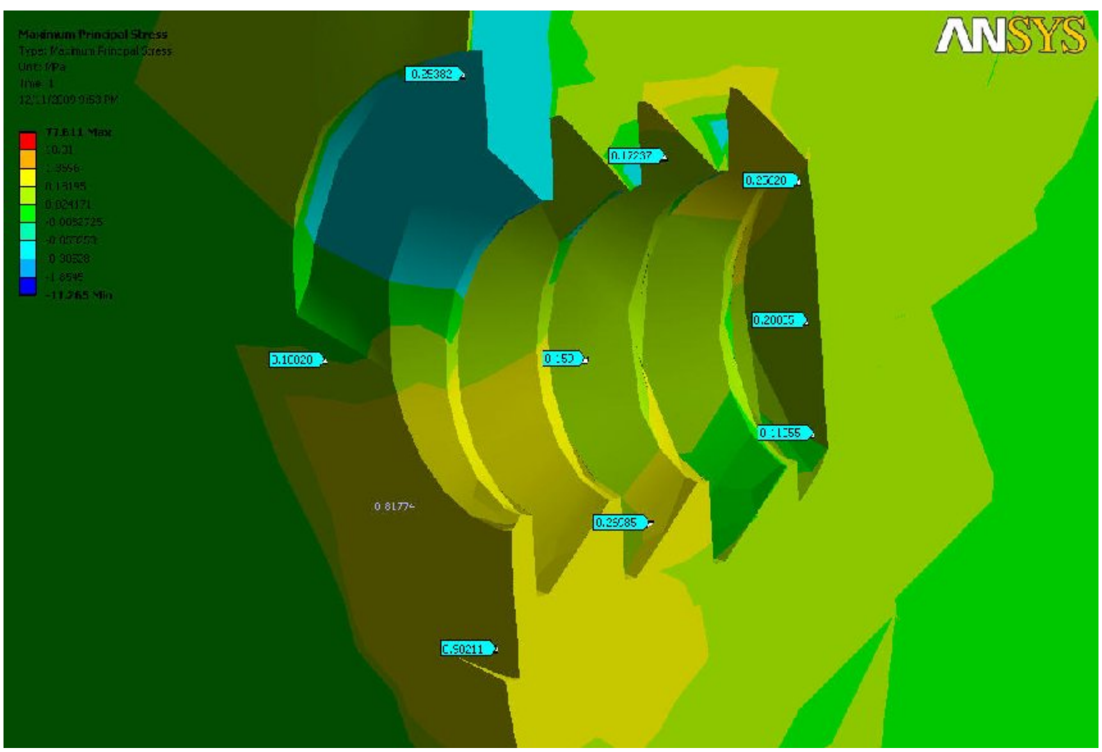


principal stress developed on temporal bone after ANALYSING IN sample j DIAMETER 3.75MM, LENGTH-3MM

FIGURE- 26- CRANIAL PART

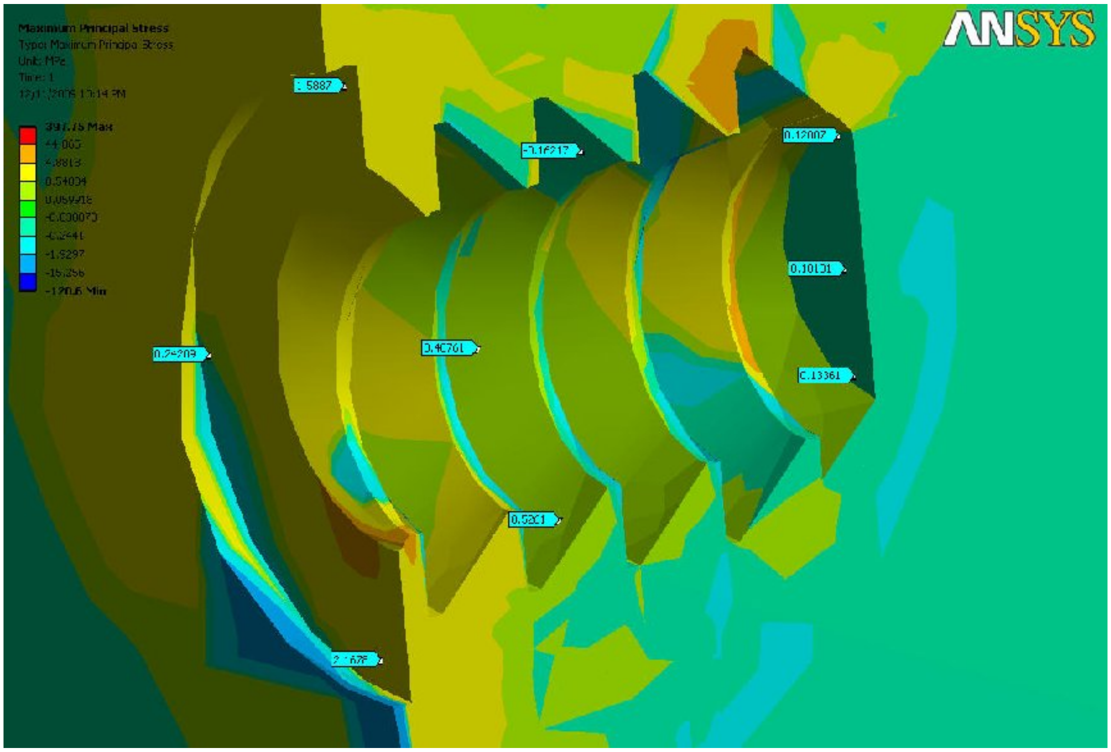


CAUDAL PART

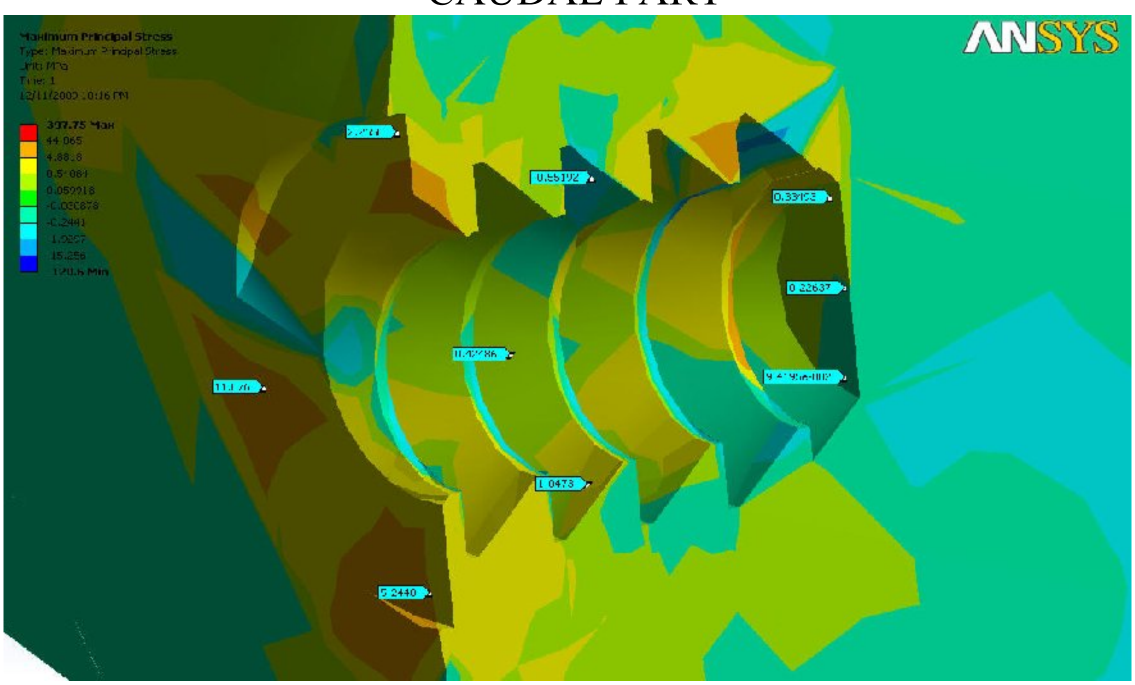


PRINCIPAL STRESS DEVELOPED ON TEMPORAL BONE AFTER ANALYSING IN SAMPLE K DIAMETER 3.75MM, LENGTH-4MM

FIGURE – 27 -CRANIAL PART

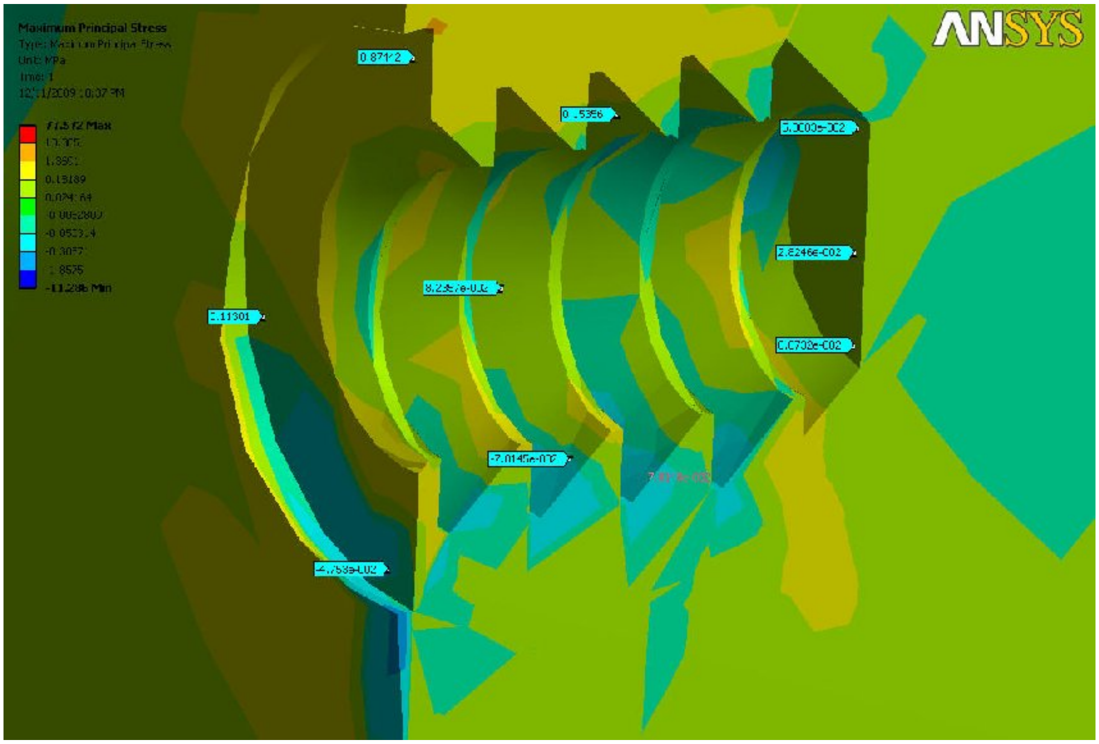


CAUDAL PART

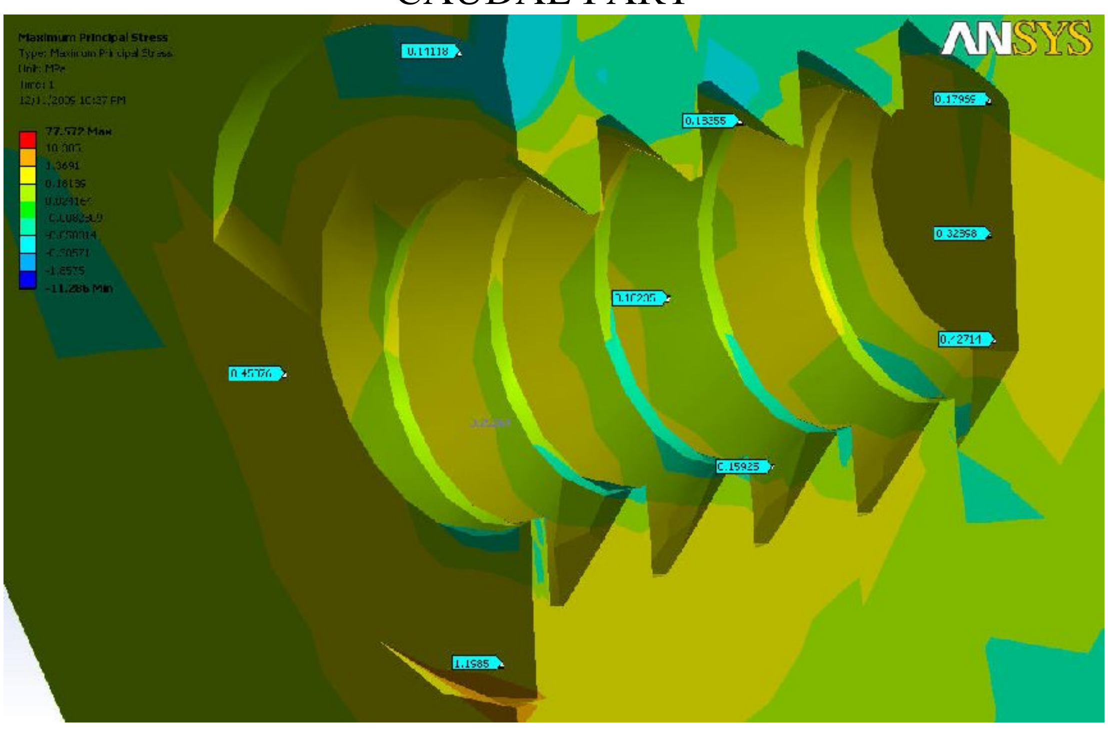


PRINCIPAL STRESS DEVELOPED ON TEMPORAL BONE AFTER ANALYSING IN SAMPLE L DIAMETER 3.75MM, LENGTH-6MM

FIGURE – 28- CRANIAL PART



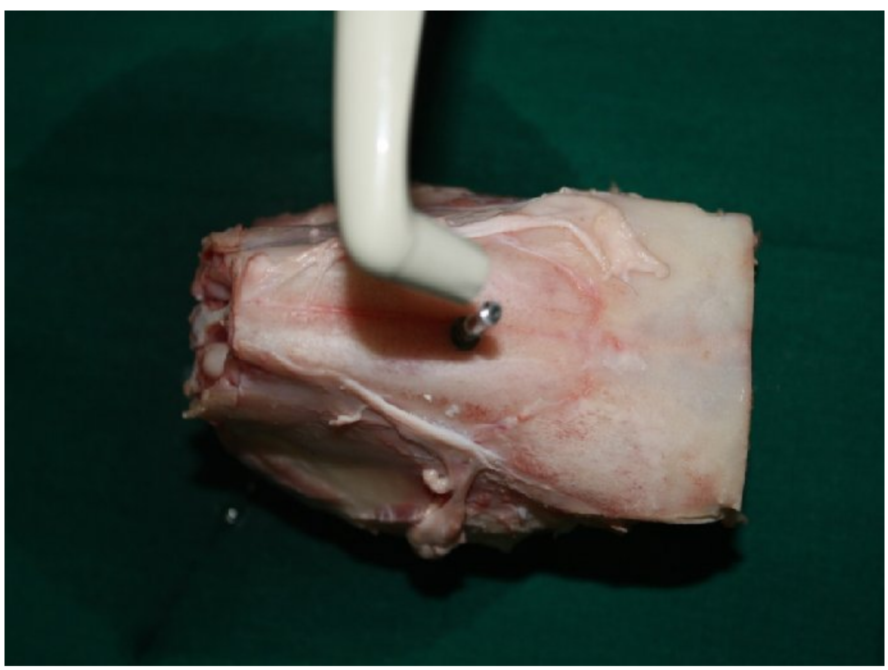
CAUDAL PART



THE PHOTOGRAPHS OF OSSTELL MENTOR WITH DEVICE-FIGURE- 29

RFA DEVICE -SMART PEG- INDEGENIOUS AND OSTELL –GERMANY - <u>FIGURE- 30</u>

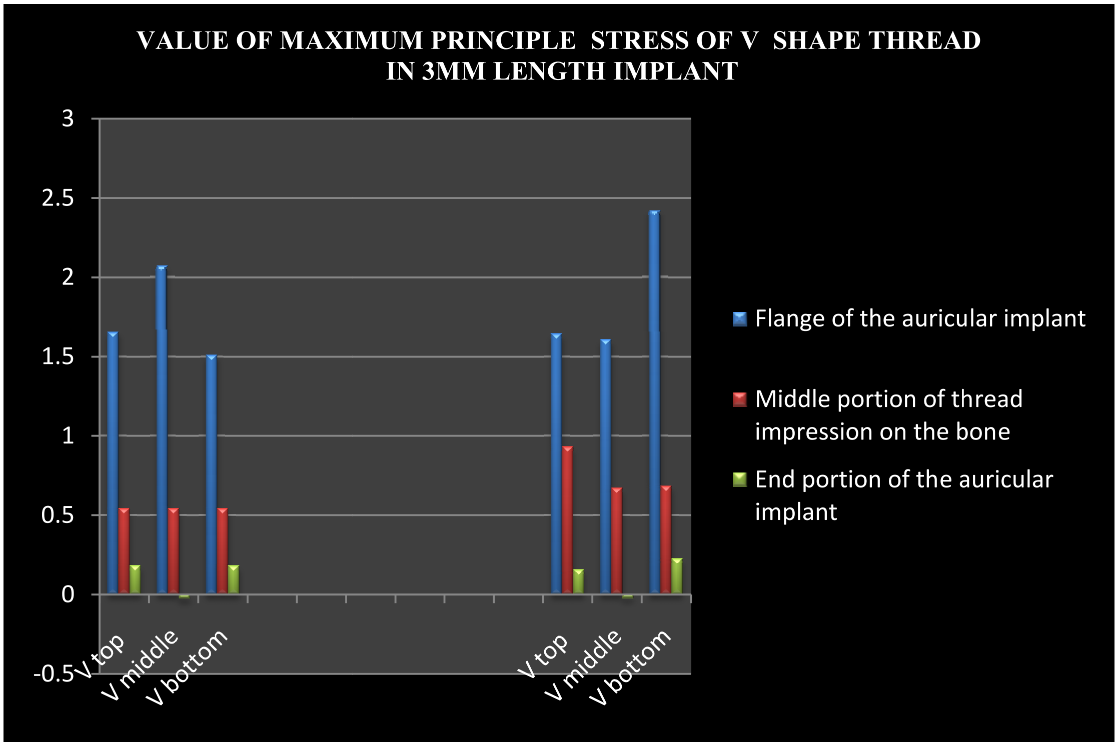
ISQ VALUE WAS MEASURED TO THE BONE SPECIMEN

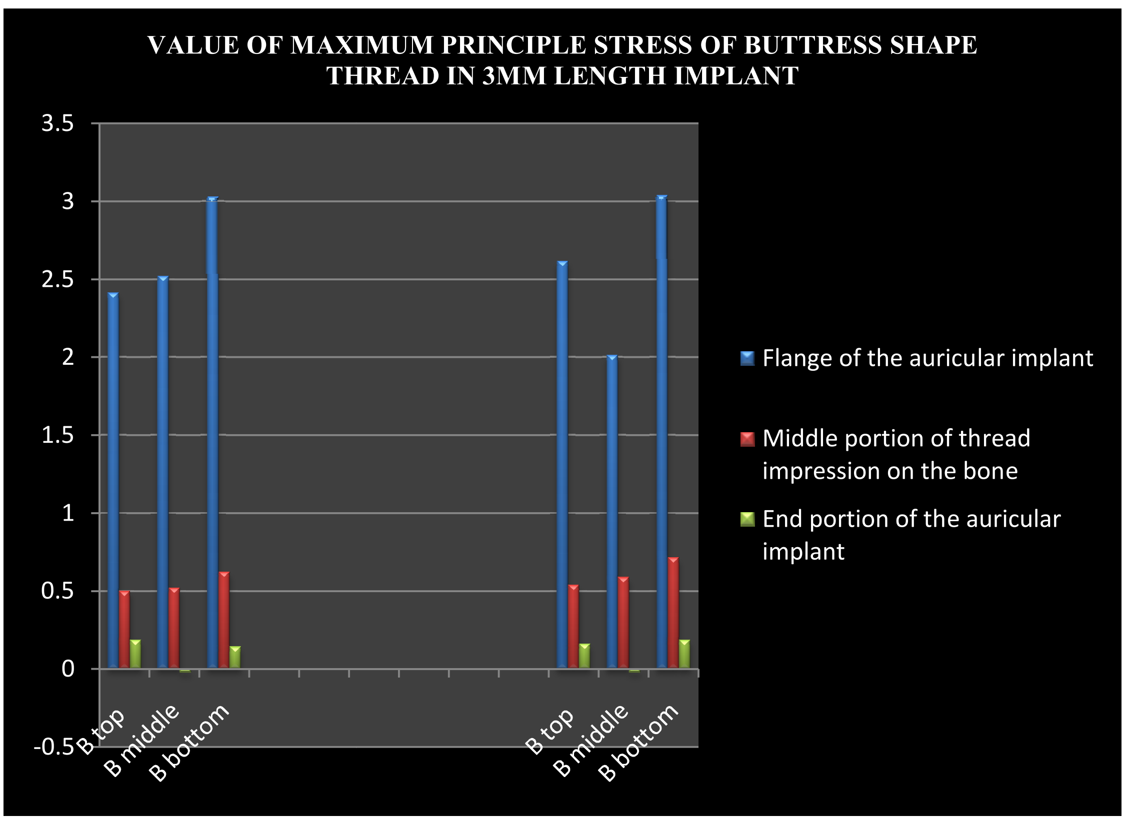


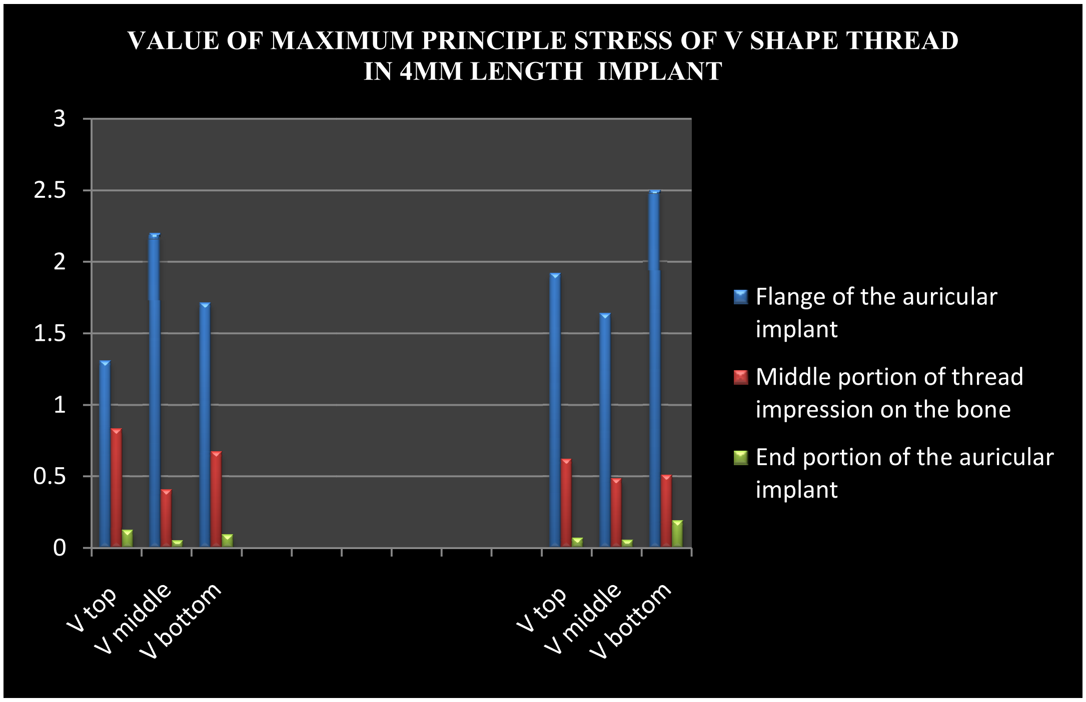
INDEGENOUS CRANIOFACIAL IMPLANT KIT FOR PLACEMENT OF AURICULAR IMPLANT

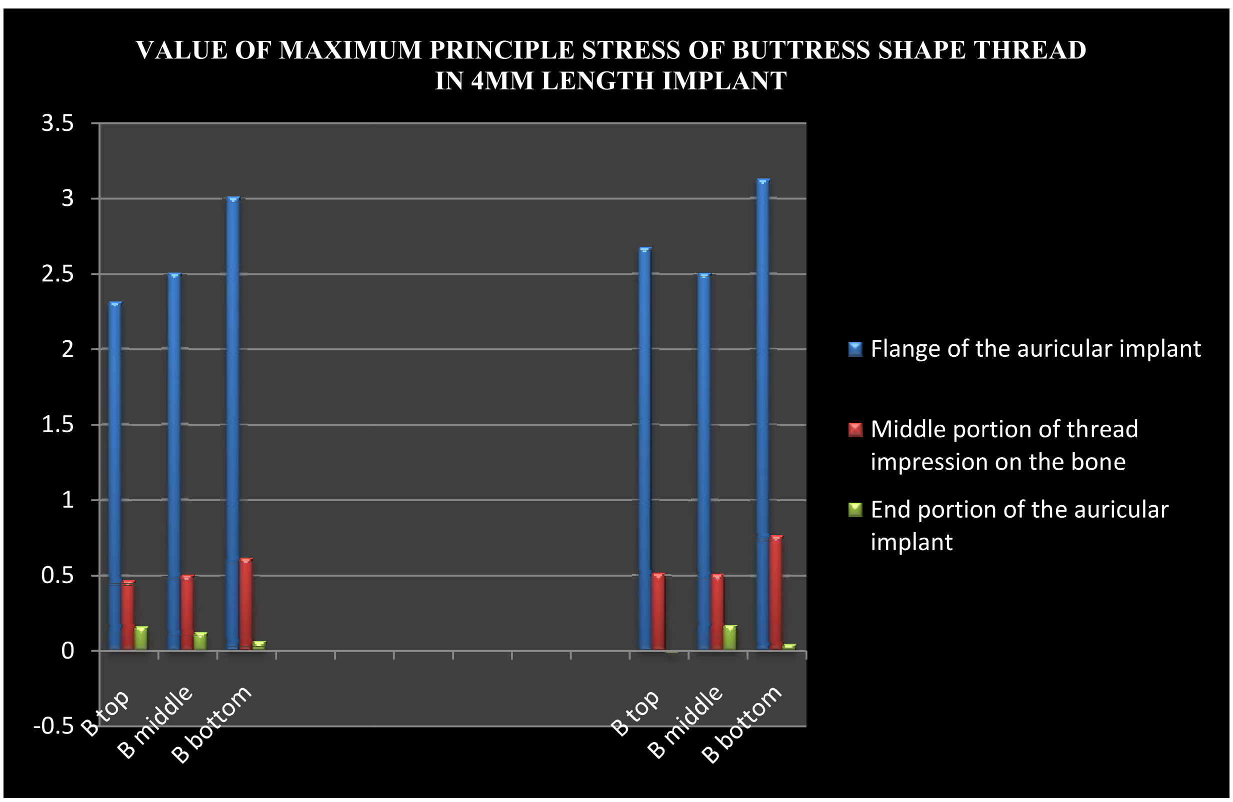
FIGURE. 31

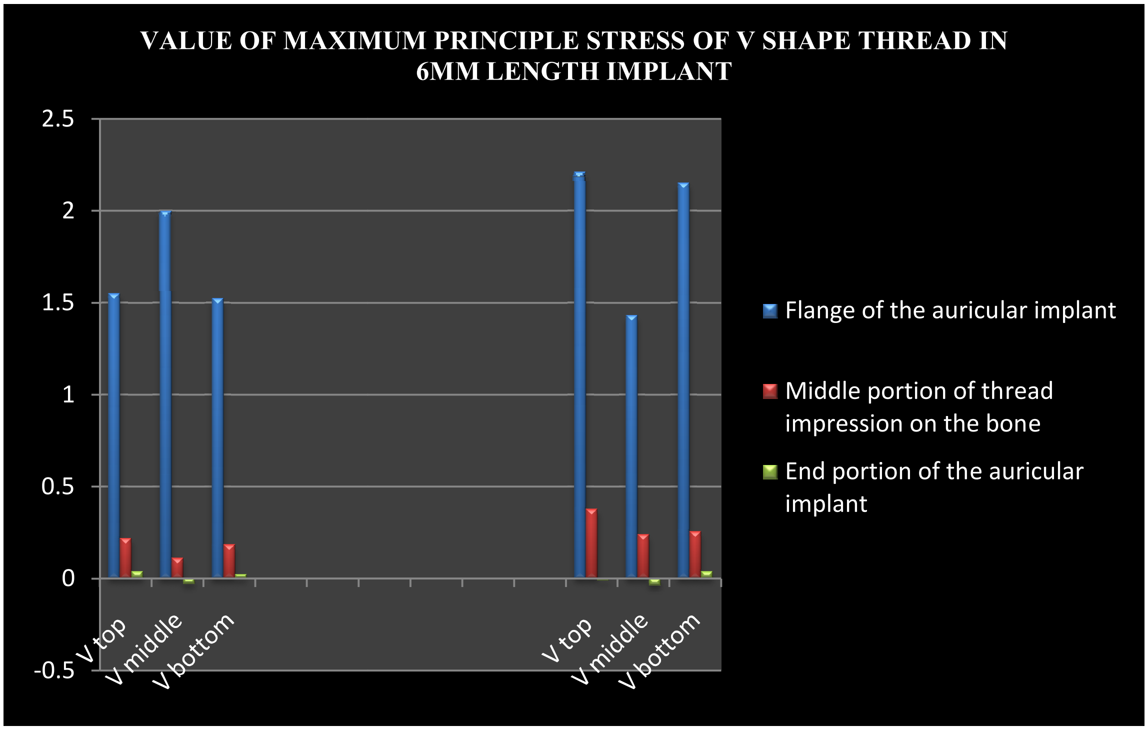
BAR DIAGRAMS

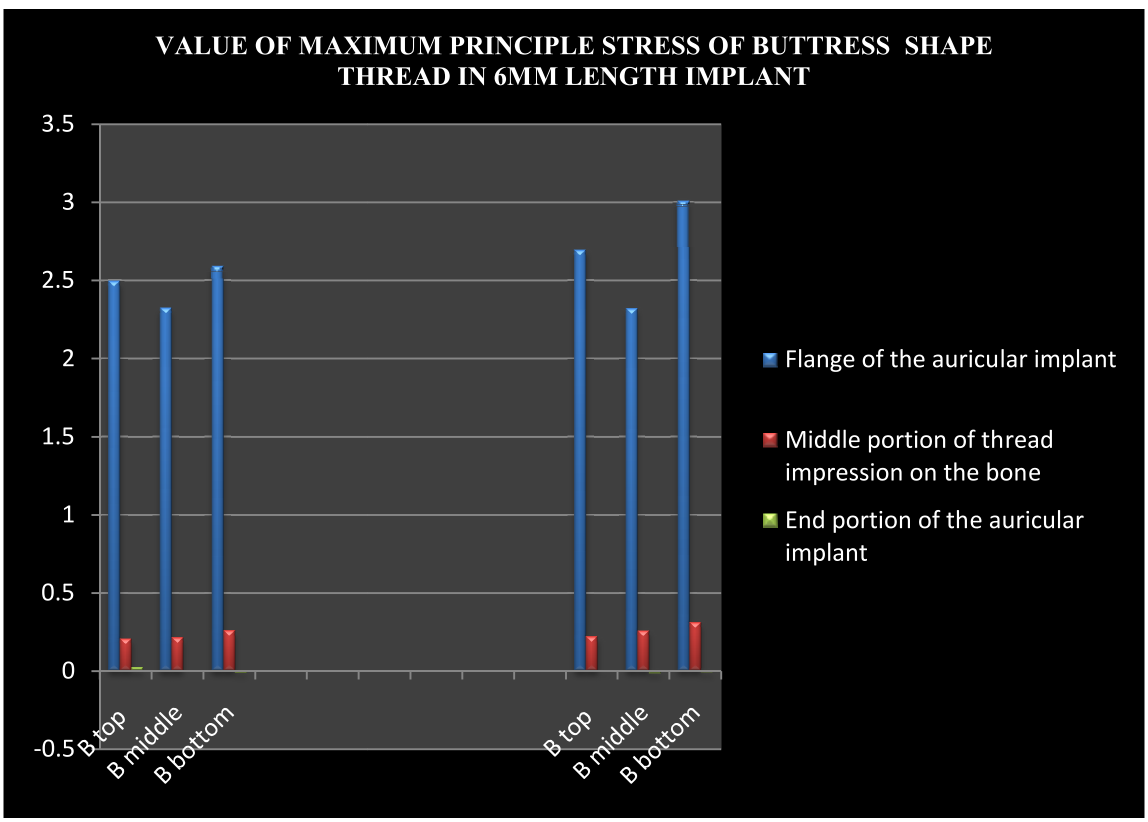

VALUE OF MAXIMUM PRINCIPLE STRESS OF V SHAPE THREAD IN 3MM LENGTH IMPLANT
3
2.5
2
1.5
1
0.5
0
-0.5
V top
V middle
V bottom
V top
V middle
V bottom
Flange of the auricular implant
Middle portion of thread impression on the bone
End portion of the auricular implant

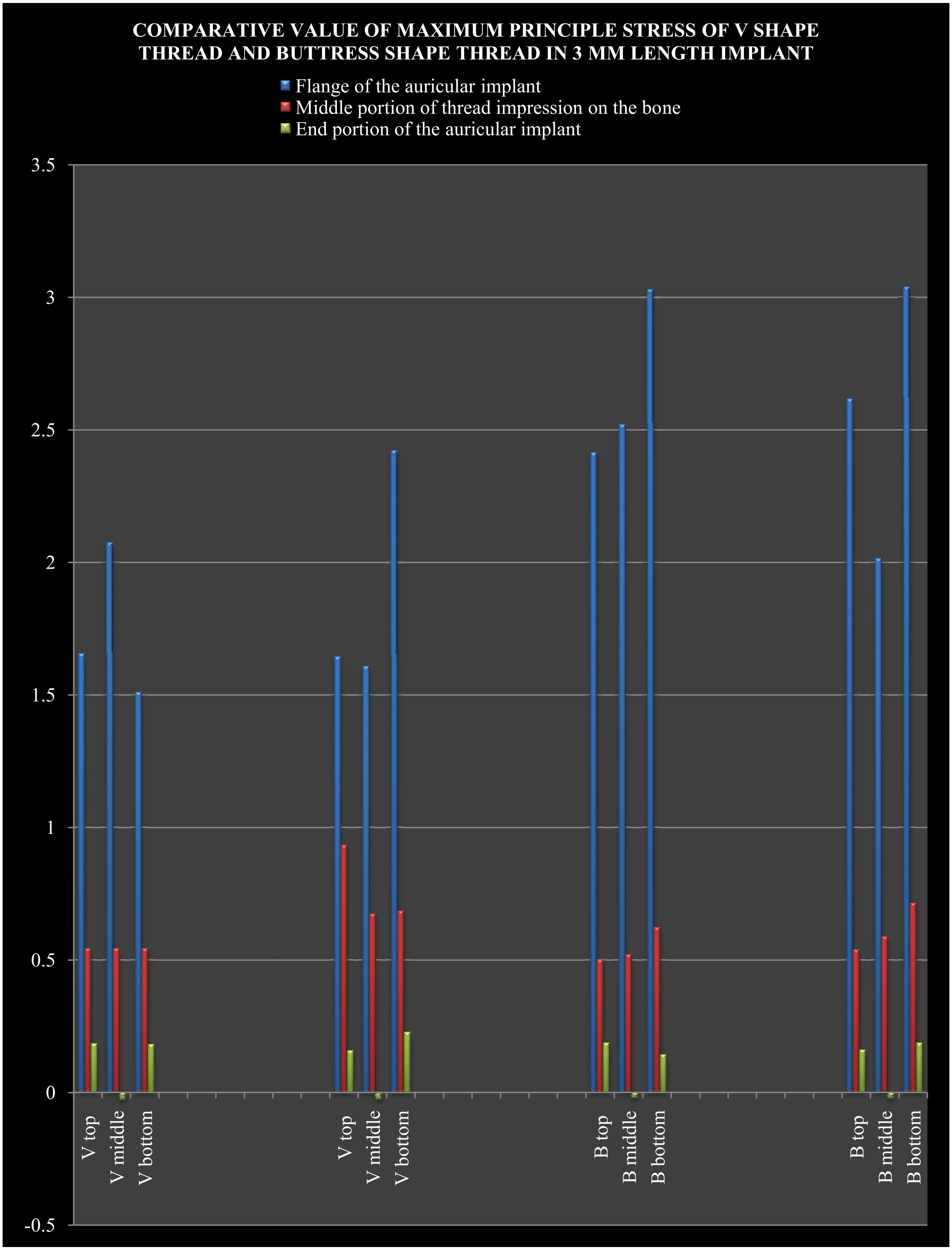

VALUE OF MAXIMUM PRINCIPLE STRESS OF BUTTRESS SHAPE THREAD IN 3MM LENGTH IMPLANT
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
B top
B middle
B bottom
B top
B middle
B bottom
Flange of the auricular implant
Middle portion of thread impression on the bone
End portion of the auricular implant

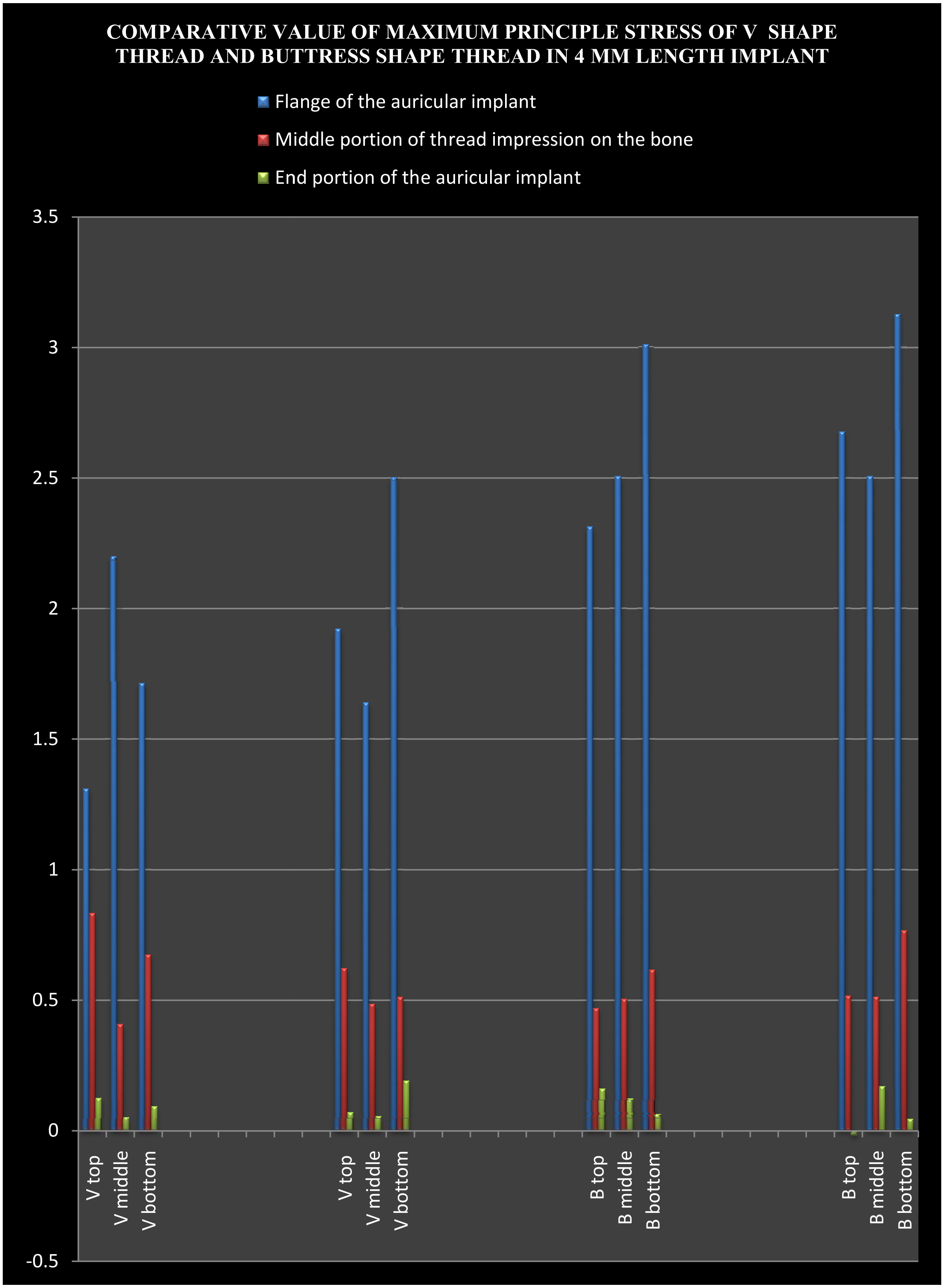

VALUE OF MAXIMUM PRINCIPLE STRESS OF V SHAPE THREAD IN 4MM LENGTH IMPLANT
3
2.5
2
1.5
1
0.5
0
V top
V middle
V bottom
V top
V middle
V bottom
Flange of the auricular implant
Middle portion of thread impression on the bone
End portion of the auricular implant


VALUE OF MAXIMUM PRINCIPLE STRESS OF BUTTRESS SHAPE THREAD IN 4MM LENGTH IMPLANT
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
B top
B middle
B bottom
B top
B middle
B bottom
Flange of the auricular implant
Middle portion of thread impression on the bone
End portion of the auricular implant

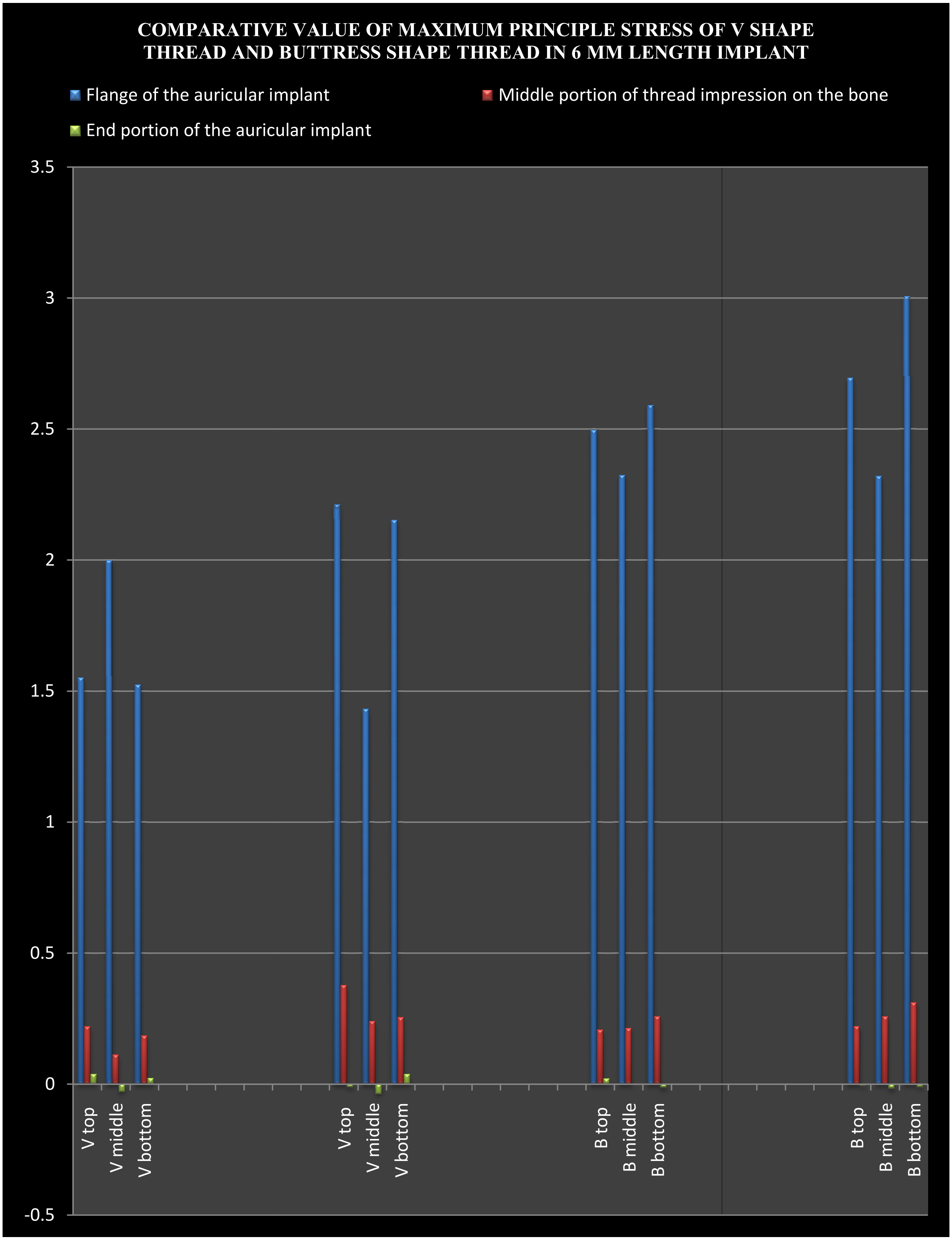

VALUE OF MAXIMUM PRINCIPLE STRESS OF V SHAPE THREAD IN 6MM LENGTH IMPLANT
2.5
2
1.5
1
0.5
0
-0.5
V top
V middle
V bottom
V top
V middle
V bottom
Flange of the auricular implant
Middle portion of thread impression on the bone
End portion of the auricular implant


VALUE OF MAXIMUM PRINCIPLE STRESS OF BUTTRESS SHAPE THREAD IN 6MM LENGTH IMPLANT
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
B top
B middle
B bottom
B top
B middle
B bottom
Flange of the auricular implant
Middle portion of thread impression on the bone
End portion of the auricular implant

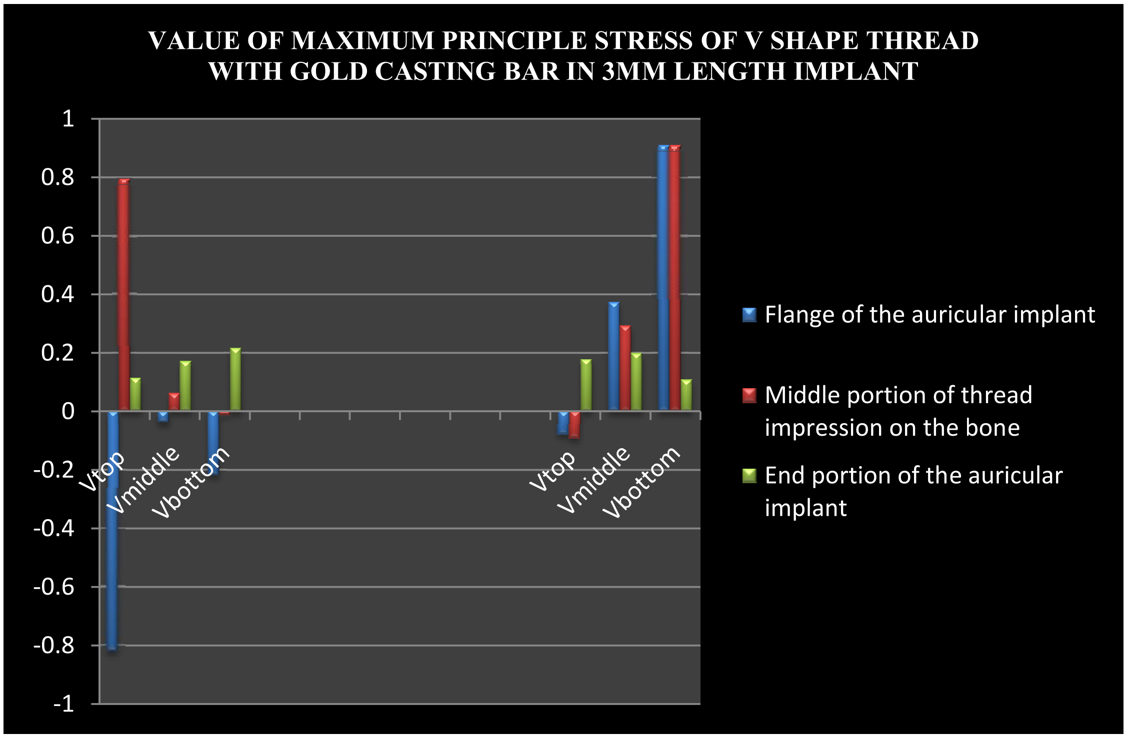

COMPARATIVE VALUE OF MAXIMUM PRINCIPLE STRESS OF V SHAPE THREAD AND BUTTRESS SHAPE THREAD IN 3 MM LENGTH IMPLANT
Flange of the auricular implant
Middle portion of thread impression on the bone
End portion of the auricular implant
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
V top
V middle
V bottom
V top
V middle
V bottom
B top
B middle
B bottom
B top
B middle
B bottom

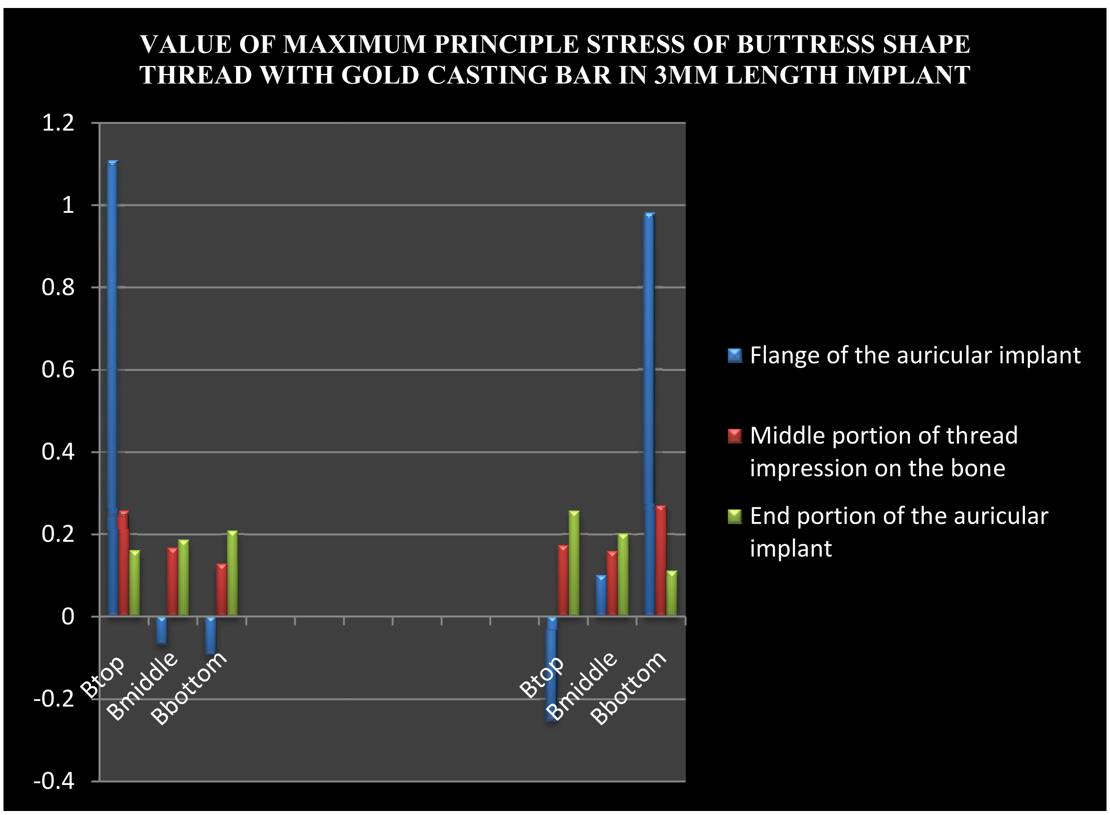


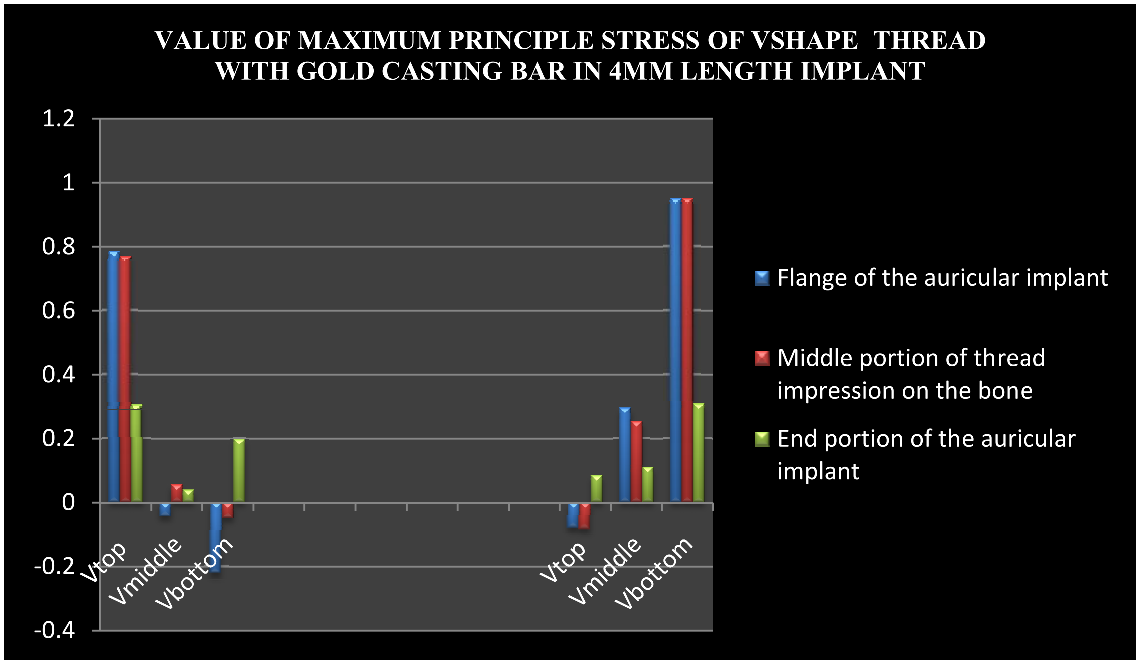
COMPARATIVE VALUE OF MAXIMUM PRINCIPLE STRESS OF V SHAPE THREAD AND BUTTRESS SHAPE THREAD IN 4 MM LENGTH IMPLANT
Flange of the auricular implant
Middle portion of thread impression on the bone
End portion of the auricular implant
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
V top
V middle
V bottom
V top
V middle
V bottom
B top
B middle
B bottom
B top
B middle
B bottom

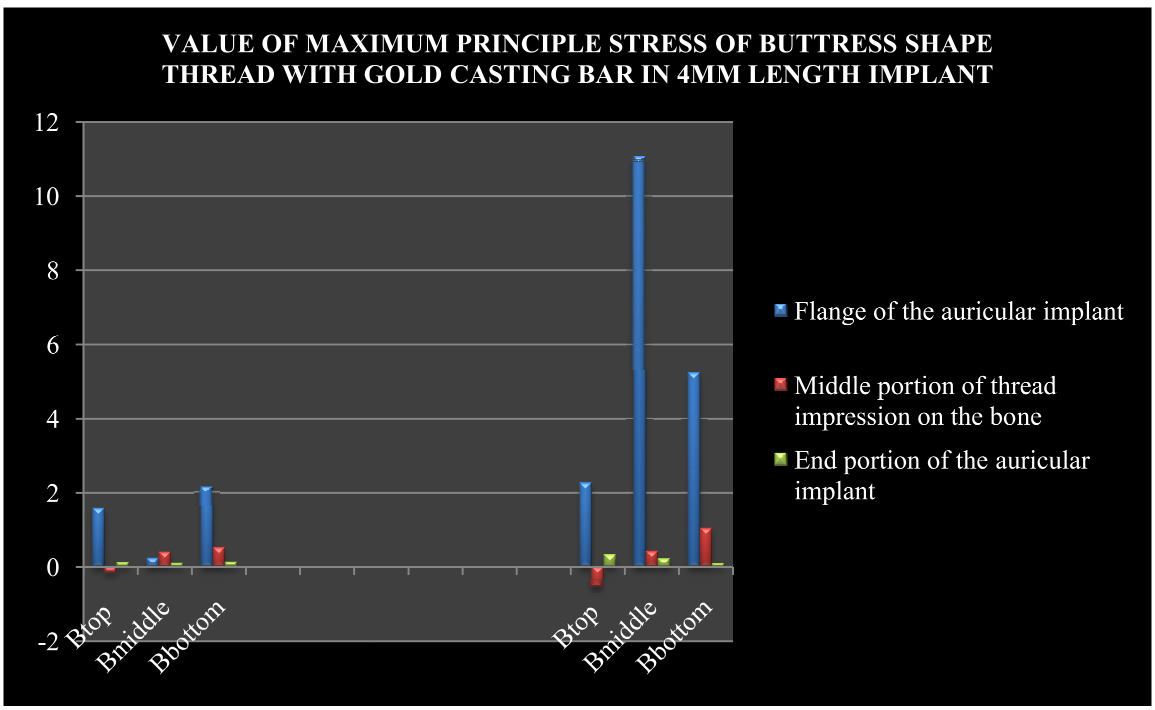


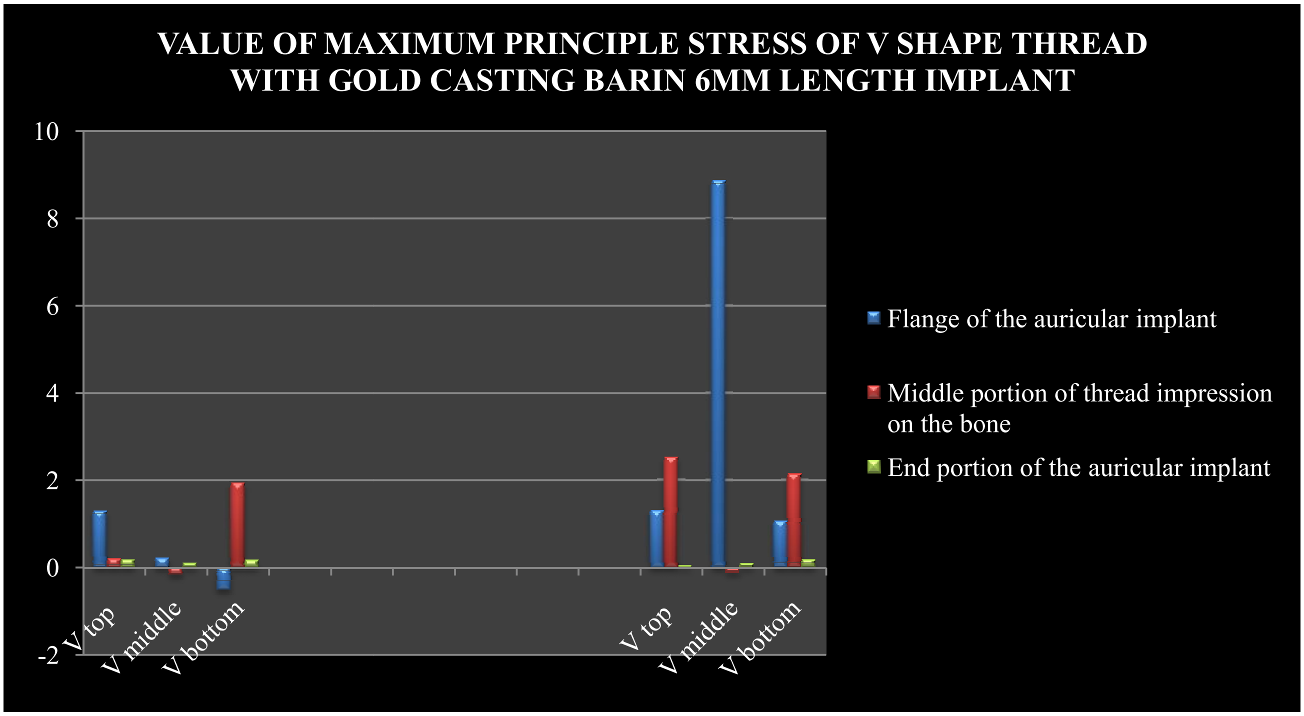
COMPARATIVE VALUE OF MAXIMUM PRINCIPLE STRESS OF V SHAPE THREAD AND BUTTRESS SHAPE THREAD IN 6 MM LENGTH IMPLANT
Flange of the auricular implant
Middle portion of thread impression on the bone
End portion of the auricular implant
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
V top
V middle
V bottom
V top
V middle
V bottom
B top
B middle
B bottom
B top
B middle
B bottom


VALUE OF MAXIMUM PRINCIPLE STRESS OF V SHAPE THREAD WITH GOLD CASTING BAR IN 3MM LENGTH IMPLANT
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
Vtop
Vmiddle
Vbottom
Vtop
Vmiddle
Vbottom
Flange of the auricular implant
Middle portion of thread impression on the bone
End portion of the auricular implant

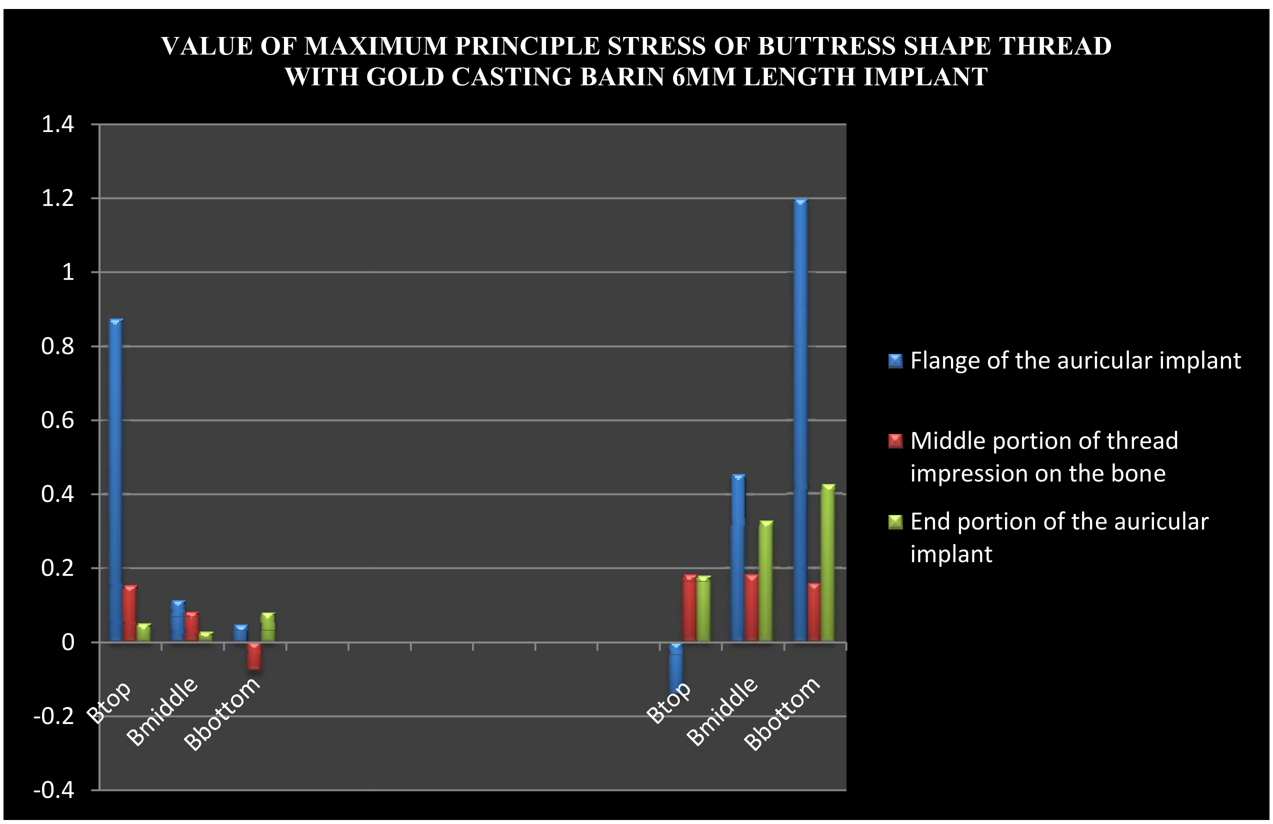

VALUE OF MAXIMUM PRINCIPLE STRESS OF BUTTRESS SHAPE THREAD WITH GOLD CASTING BAR IN 3MM LENGTH IMPLANT
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
Btop
Bmiddle
Bbottom
Btop
Bmiddle
Bbottom
Flange of the auricular implant
Middle portion of thread impression on the bone
End portion of the auricular implant


VALUE OF MAXIMUM PRINCIPLE STRESS OF VSHAPE THREAD WITH GOLD CASTING BAR IN 4MM LENGTH IMPLANT
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
Vtop
Vmiddle
Vbottom
Vtop
Vmiddle
Vbottom
Flange of the auricular implant
Middle portion of thread impression on the bone
End portion of the auricular implant

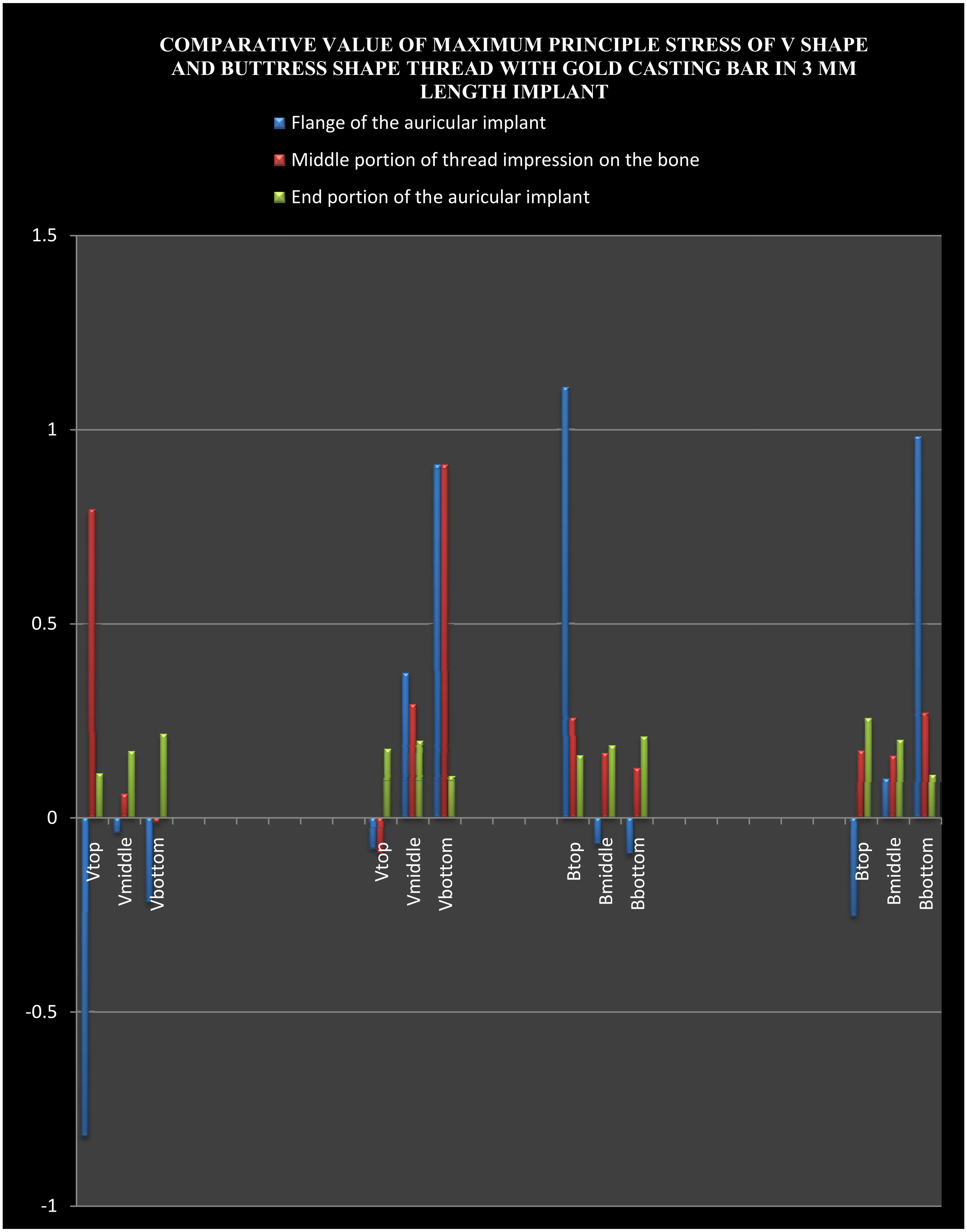

VALUE OF MAXIMUM PRINCIPLE STRESS OF BUTTRESS SHAPE THREAD WITH GOLD CASTING BAR IN 4MM LENGTH IMPLANT
12
10
8
6
4
2
0
-2
Btop
Bmiddle
Bbottom
Btop
Bmiddle
Bbottom
Flange of the auricular implant
Middle portion of thread impression on the bone
End portion of the auricular implant

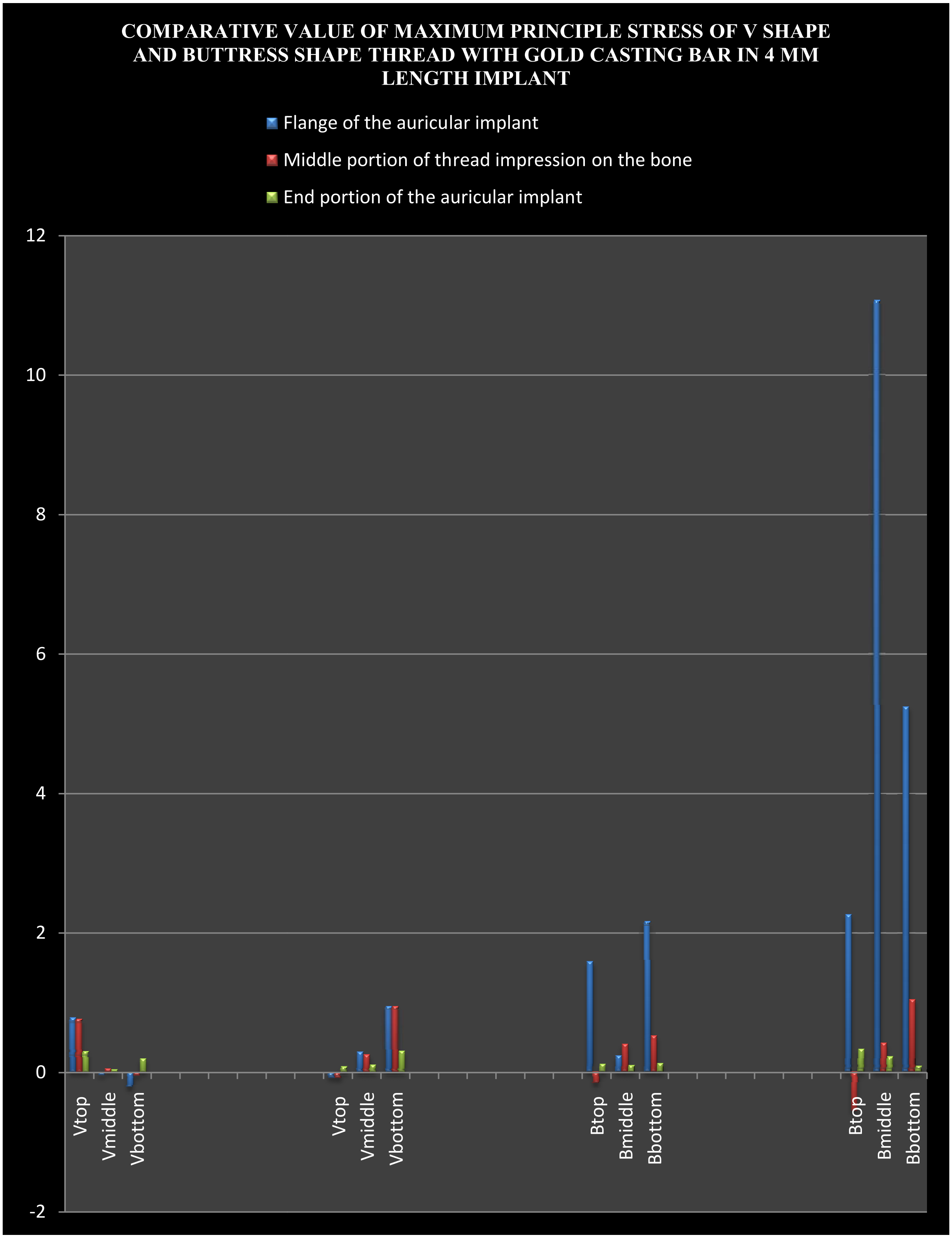


VALUE OF MAXIMUM PRINCIPLE STRESS OF V SHAPE THREAD
WITH GOLD CASTING BARIN 6MM LENGTH IMPLANT
10
8
6
4
2
0
-2
V top
V middle
V bottom
V top
V middle
V bottom
Flange of the auricular implant
Middle portion of thread impression on the bone
End portion of the auricular implant

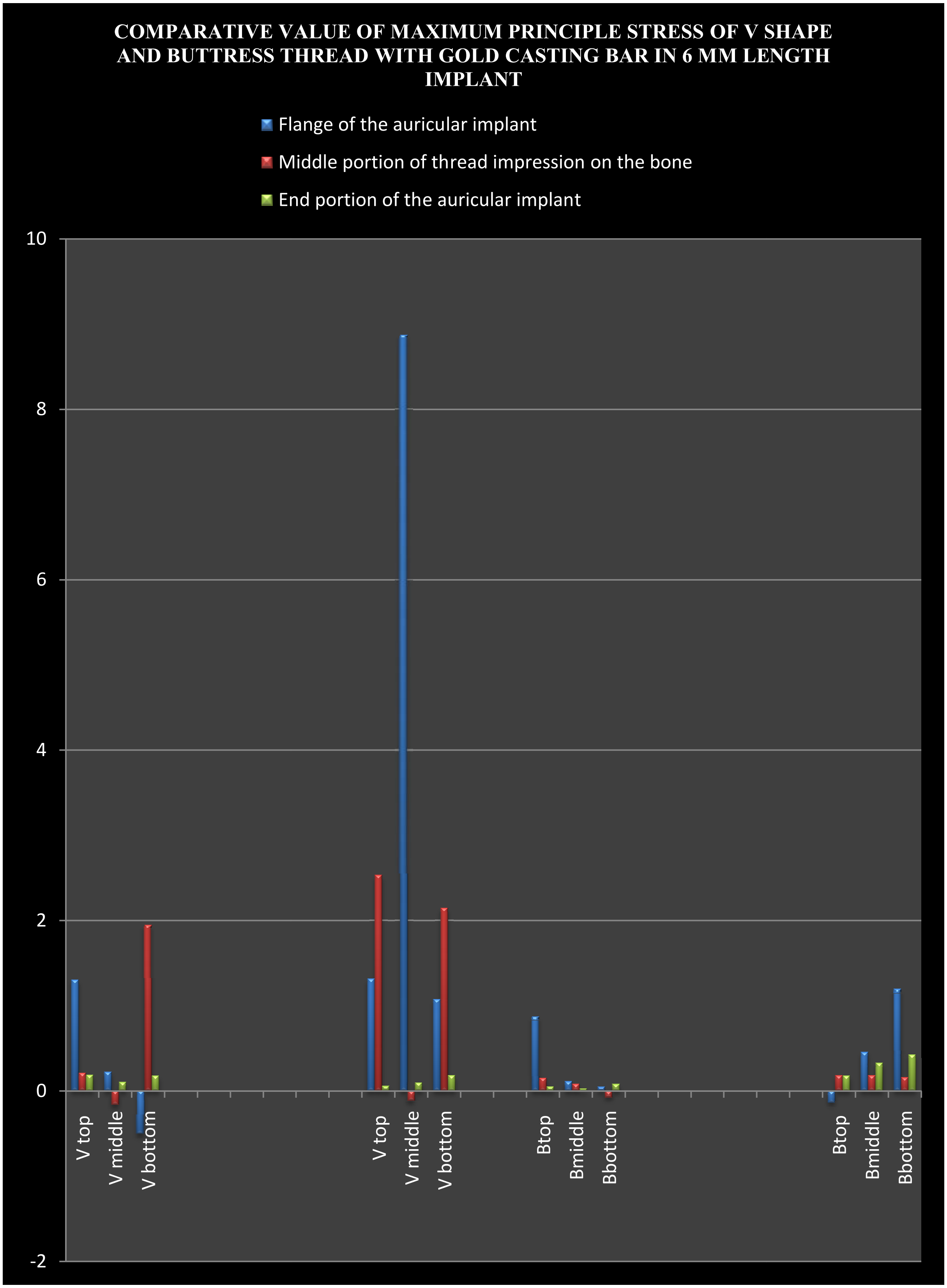


VALUE OF MAXIMUM PRINCIPLE STRESS OF BUTTRESS SHAPE THREAD
WITH GOLD CASTING BARIN 6MM LENGTH IMPLANT
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
Btop
Bmiddle
Bbottom
Btop
Bmiddle
Bbottom
Flange of the auricular implant
Middle portion of thread impression on the bone
End portion of the auricular implant


COMPARATIVE VALUE OF MAXIMUM PRINCIPLE STRESS OF V SHAPE AND BUTTRESS SHAPE THREAD WITH GOLD CASTING BAR IN 3 MM LENGTH IMPLANT
Flange of the auricular implant
Middle portion of thread impression on the bone
End portion of the auricular implant
1.5
1
0.5
0
-0.5
-1
Vtop
Vmiddle
Vbottom
Vtop
Vmiddle
Vbottom
Btop
Bmiddle
Bbottom
Btop
Bmiddle
Bbottom



COMPARATIVE VALUE OF MAXIMUM PRINCIPLE STRESS OF V SHAPE AND BUTTRESS SHAPE THREAD WITH GOLD CASTING BAR IN 4 MM LENGTH IMPLANT
Flange of the auricular implant
Middle portion of thread impression on the bone
End portion of the auricular implant
12
10
8
6
4
2
0
-2
Vtop
Vmiddle
Vbottom
Vtop
Vmiddle
Vbottom
Btop
Bmiddle
Bbottom
Btop
Bmiddle
Bbottom


COMPARATIVE VALUE OF MAXIMUM PRINCIPLE STRESS OF V SHAPE AND BUTTRESS THREAD WITH GOLD CASTING BAR IN 6 MM LENGTH IMPLANT
Flange of the auricular implant
Middle portion of thread impression on the bone
End portion of the auricular implant
10
8
6
4
2
0
-2
V top
V middle
V bottom
V top
V middle
V bottom
Btop
Bmiddle
Bbottom
Btop
Bmiddle
Bbottom

RESULTS

RESULTS

The basic data of the results of this study are shown in annexure from Table 1 to Table 13. In this study, the maximum value of Principle stress in mega Pascal calculated in the temporal bone surrounding the craniofacial auriclar implant of commercially available implants and indigenously made implants.

Then, the results are analyzed using the following Statistical analysis.

- Student's' test used to assess the significant difference between two group of craniofacial auricular implants followed by the Independent sample test.
- If no significant exist in the Independent sample test, Non-Parameter test was done – Mann- Whitney test.
- Table 1 and Table 2 shows Group Statistics for mean and standard deviation for cranial and caudal part of auricular implants for V-shape thread design and Buttress-shape thread design for 3mm length implant.
- Table 3 and Table 4 shows Group statistics for mean and standard deviation for cranial and caudal part of auricular implants for V-shape

thread design and Buttress-shape thread design for 4mm length implant.

- Table 5 and Table 6 shows Group statistics for mean and standard deviation for cranial and caudal part of auricular implants for V-shape thread design and Buttress-shape thread design for 6mm length implant.
- Table 7 and Table 8 shows Group Statistics for mean and standard deviation for cranial and caudal part of auricular implants connected by a bar for V-shape thread design and Buttress-shape thread design for 3mm length implant.
- Table 9 and Table 10 shows Group statistics for mean and standard deviation for cranial and caudal part of auricular implants connected by a bar for V-shape thread design and Buttress-shape thread design for 4mm length implant.
- Table 11 and Table 12 shows Group statistics for mean and standard deviation for cranial and caudal part of auricular implants connected by a bar for V-shape thread design and Buttress-shape thread design for 6mm length implant.

- Table 13shows shows Group statistics for mean and standard deviation for V-shape thread design and Buttress-shape thread design for 3mm length implant.

INTERPRETATION OF RESULTS

The basic data obtained after Finite element analysis for this study is presented in Table 1 to Table 12.

- Inference from Table 1 and Table 2: The flange of the craniofacial auricular implant was found to be statistically significant with the probability value of 0.023 for V-shaped thread design and 0.024 for Buttress-shape thread design for a implant length of 3mm with diameter 3.75. The middle portion of the thread and the end portion were found to be insignificant. The stress concentration was found to be more in the flange are for V-shape thread design.
- Inference from Table 3 to Table 6 The flange of the craniofacial auricular implant was found to be statistically insignificant with the probability value very minimal for V-shaped thread design and Buttress-shape thread design for an implant length for a length of

4mm and 6mm length respectively. The overall maximum principal stress concentration in the temporal region was found to be greater for 3mm length of implant with diameter 3.75mm in the flange area of the implant when compared to 4mm and 6mm length.

- Inference from Table 7- Table 12: The overall maximum principal stress concentration in the temporal region with two implant placement both in cranial part and caudal part connected by a bar shows negative result. This infers that stress is very minimal to the bone and it is taken up by the bar which proves statistically insignificant.

VALUES OF RADIO-FREQUENCY ANALYSIS

	SITE I	SITE II	SITE III	SITE IV	SITE V
CONVENTIONAL CRANIOFACIAL AURICULAR IMPLANT	**32**	**42**	**42**	**39**	**39**
	34	**46**	**46**	**41**	**37**
	32	**46**	**46**	**41**	**41**
INDEGINOUS CRANIOFACIAL AURICULAR IMPLANT	**67**	**61**	**59**	**62**	**57**
	65	**64**	**57**	**66**	**57**
	67	**62**	**57**	**69**	**59**

3MM CRANIAL PART T-TEST- TABLE -1

Group Statistics

	SAMPLE	N	Mean	Std. Deviation	Std. Error Mean
Flange of the auricular implant	A	3	1.746200	.2931157	.1692304
	D	3	2.654067	.3293408	.1901450
Middle portion of thread impression on the bone	A	3	.5425800	.00000000	.00000000
	D	3	.5477733	.06557071	.03785727
End portion of the auricular implant	A	3	.112436	.1217685	.0703031
	D	3	.102379	.1102356	.0636445

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Flange of the auricu implant	Equal varianc assumed	.104	.763	-3.567	4	.023	.9078667	.2545468	-1.61460	2011316
	Equal varianc not assumed			-3.567	3.947	.024	.9078667	.2545468	-1.61837	1973652
Middle portion of thr impression on the b	Equal varianc assumed	13.332	.022	-.137	4	.898	00519333	03785727	-.110302	9991530
	Equal varianc not assumed			-.137	2.000	.903	00519333	03785727	-.168080	5769335
End portion of the auricular implant	Equal varianc assumed	.098	.770	.106	4	.921	.0100570	.0948322	2532395	2733535
	Equal varianc not assumed			.106	3.961	.921	.0100570	.0948322	2542639	2743779

NPar Tests

Mann-Whitney Test

Ranks

	SAMPLE	N	Mean Rank	Sum of Ranks
End portion of the auricular implant	A	3	3.33	10.00
	D	3	3.67	11.00
	Total	6		

Test Statistics[b]

	End portion of the auricular implant
Mann-Whitney U	4.000
Wilcoxon W	10.000
Z	-.218
Asymp. Sig. (2-tailed)	.827
Exact Sig. [2*(1-tailed Sig.)]	1.000[a]

a. Not corrected for ties.

b. Grouping Variable: SAMPLE

3 MM CAUDAL PART T-TEST- TABLE-2

Group Statistics

	SAMPLE	N	Mean	Std. Deviation	Std. Error Mean
Flange of the auricular implant	A	3	1.890967	.4599887	.2655746
	D	3	2.556367	.5153380	.2975306
Middle portion of thread impression on the bone	A	3	.7636667	.14710385	.08493045
	D	3	.6137567	.09069754	.05236425
End portion of the auricular implant	A	3	.119590	.1309925	.0756286
	D	3	.108200	.1141276	.0658916

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Flange of the auricular implant	Equal variances assumed	.002	.966	-1.668	4	.171	-.6654000	.3988161	-1.77269	.4418911
	Equal variances not assumed			-1.668	3.949	.171	-.6654000	.3988161	-1.77830	.4475030
Middle portion of thread impression on the bone	Equal variances assumed	1.630	.271	1.502	4	.207	.14991000	.09977573	-.127112	.42693183
	Equal variances not assumed			1.502	3.329	.221	.14991000	.09977573	-.150605	.45042466
End portion of the auricular implant	Equal variances assumed	.066	.810	.114	4	.915	.0113900	.1003064	-.2671053	.2898853
	Equal variances not assumed			.114	3.926	.915	.0113900	.1003064	-.2691776	.2919576

NPar Tests

Mann-Whitney Test

Ranks

	SAMPLE	N	Mean Rank	Sum of Ranks
End portion of the auricular implant	A	3	3.33	10.00
	D	3	3.67	11.00
	Total	6		

Test Statistics[b]

	End portion of the auricular implant
Mann-Whitney U	4.000
Wilcoxon W	10.000
Z	-.218
Asymp. Sig. (2-tailed)	.827
Exact Sig. [2*(1-tailed Sig.)]	1.000[a]

a. Not corrected for ties.

b. Grouping Variable: SAMPLE

4 MM CRANIAL PART T-TEST- TABLE -3

Group Statistics

	SAMPLE	N	Mean	Std. Deviation	Std. Error Mean
Flange of the auricular implant	B	3	1.741167	.4459257	.2574553
	E	3	2.610300	.3606281	.2082087
Middle portion of thread impression on the bone	B	3	.6378100	.21536092	.12433869
	E	3	.5288833	.07744199	.04471116
End portion of the auricular implant	B	3	.089083	.0368810	.0212933
	E	3	.115495	.0486119	.0280661

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Flange of the auricular implant	Equal variances assumed	.055	.826	-2.625	4	.058	-.8691333	.3311104	-1.78844	.0501766
	Equal variances not assumed			-2.625	3.832	.061	-.8691333	.3311104	-1.80453	.0662588
Middle portion of threa impression on the bon	Equal variances assumed	2.355	.200	.824	4	.456	.10892667	.13213325	-.257934	47578739
	Equal variances not assumed			.824	2.509	.481	.10892667	.13213325	-.362232	58008504
End portion of the auricular implant	Equal variances assumed	.254	.641	-.750	4	.495	-.0264120	.0352294	-.1242244	.0714004
	Equal variances not assumed			-.750	3.729	.498	-.0264120	.0352294	-.1270877	.0742637

4 MM CAUDAL PART T-TEST- TABLE-4

Group Statistics

	SAMPLE	N	Mean	Std. Deviation	Std. Error Mean
Flange of the auricular implant	B	3	2.021000	.4395108	.2537517
	E	3	2.770167	.3212474	.1854723
Middle portion of thread impression on the bone	B	3	.5394000	.07213619	.04164785
	E	3	.5977767	.14537860	.08393437
End portion of the auricular implant	B	3	.105295	.0749010	.0432441
	E	3	.065617	.0955241	.0551508

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Flange of the auricular implant	Equal variances assumed	.353	.584	-2.384	4	.076	-.7491667	.3143086	-1.62183	.1234938
	Equal variances not assumed			-2.384	3.662	.082	-.7491667	.3143086	-1.65448	.1561441
Middle portion of thread impression on the bone	Equal variances assumed	3.194	.148	-.623	4	.567	-.05837667	.09369911	-.318527	.20177376
	Equal variances not assumed			-.623	2.929	.578	-.05837667	.09369911	-.360727	.24397392
End portion of the auricular implant	Equal variances assumed	.173	.699	.566	4	.602	.0396780	.0700833	-.1549045	.2342605
	Equal variances not assumed			.566	3.785	.603	.0396780	.0700833	-.1593493	.2387053

NPar Tests

Mann-Whitney Test

Ranks

	SAMPLE	N	Mean Rank	Sum of Ranks
End portion of the auricular implant	B	3	4.33	13.00
	E	3	2.67	8.00
	Total	6		

Test Statistics[b]

	End portion of the auricular implant
Mann-Whitney U	2.000
Wilcoxon W	8.000
Z	-1.091
Asymp. Sig. (2-tailed)	.275
Exact Sig. [2*(1-tailed Sig.)]	.400[a]

a. Not corrected for ties.

b. Grouping Variable: SAMPLE

6 MM CRANIAL PART T-TEST- TABLE-5

Group Statistics

	SAMPLE	N	Mean	Std. Deviation	Std. Error Mean
Flange of the auricular implant	C	3	1.691133	.2669469	.1541219
	F	3	2.470300	.1358150	.0784128
Middle portion of thread impression on the bone	C	3	.1714900	.05469798	.03157989
	F	3	.2255900	.02807100	.01620680
End portion of the auricular implant	C	3	.010122	.0355944	.0205504
	F	3	.001214	.0181038	.0104522

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Flange of the auricular implant	Equal variances assumed	2.848	.167	-4.506	4	.011	-.7791667	.1729223	-1.25928	-.2990574
	Equal variances not assumed			-4.506	2.970	.021	-.7791667	.1729223	-1.33260	-.2257328
Middle portion of thread impression on the bone	Equal variances assumed	1.453	.295	-1.524	4	.202	-.05410000	.03549577	-.152652	.04445207
	Equal variances not assumed			-1.524	2.985	.225	-.05410000	.03549577	-.167382	.05918176
End portion of the auricular implant	Equal variances assumed	2.141	.217	.386	4	.719	.0089078	.0230558	-.0551053	.0729209
	Equal variances not assumed			.386	2.970	.725	.0089078	.0230558	-.0648893	.0827049

6 MM CAUDAL PART T-TEST- TABLE- 6

Group Statistics

	SAMPLE	N	Mean	Std. Deviation	Std. Error Mean
Flange of the auricular implant	C	3	1.931667	.4343503	.2507722
	F	3	2.673933	.3439934	.1986047
Middle portion of thread impression on the bone	C	3	.2904100	.07576001	.04374006
	F	3	.2624367	.04549044	.02626392
End portion of the auricular implant	C	3	-.004500	.0384380	.0221922
	F	3	-.012342	.0055108	.0031816

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Flange of the auricular implant	Equal variances assumed	.505	.517	-2.320	4	.081	-.7422667	.3198914	-1.63043	.1458944
	Equal variances not assumed			-2.320	3.801	.085	-.7422667	.3198914	-1.64912	.1645830
Middle portion of thread impression on the bone	Equal variances assumed	1.662	.267	.548	4	.613	.02797333	.05101947	-.113679	.16962609
	Equal variances not assumed			.548	3.276	.619	.02797333	.05101947	-.126916	.18286258
End portion of the auricular implant	Equal variances assumed	5.568	.078	.350	4	.744	.0078423	.0224191	-.0544031	.0700877
	Equal variances not assumed			.350	2.082	.759	.0078423	.0224191	-.0850611	.1007458

3 MM CRANIAL PART T-TEST TABLE -7

Group Statistics

	SAMPLE	N	Mean	Std. Deviation	Std. Error Mean
Flange of the auricular implant	G	3	-.359290	.4097536	.2365713
	J	3	.315833	.6871977	.3967538
Middle portion of thread impression on the bone	G	3	.2809967	.44623901	.25763621
	J	3	.1838067	.06660368	.03845365
End portion of the auricular implant	G	3	.166913	.0511027	.0295042
	J	3	.185000	.0235160	.0135769

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Flange of the auricular implant	Equal variances assumed	1.870	.243	-1.462	4	.218	-.6751233	.4619303	-1.95765	.6074007
	Equal variances not assumed			-1.462	3.263	.233	-.6751233	.4619303	-2.08048	.7302338
Middle portion of thread impression on the bone	Equal variances assumed	10.675	.031	.373	4	.728	.09719000	.26049012	-.626047	.82042651
	Equal variances not assumed			.373	2.089	.744	.09719000	.26049012	-.979040	1.173420
End portion of the auricular implant	Equal variances assumed	1.239	.328	-.557	4	.607	-.0180867	.0324781	-.1082604	.0720871
	Equal variances not assumed			-.557	2.811	.619	-.0180867	.0324781	-.1254991	.0893257

NPar Tests

Mann-Whitney Test

Ranks

	SAMPLE	N	Mean Rank	Sum of Ranks
Flange of the auricular implant	G	3	2.67	8.00
	J	3	4.33	13.00
	Total	6		
Middle portion of thread impression on the bone	G	3	3.00	9.00
	J	3	4.00	12.00
	Total	6		
End portion of the auricular implant	G	3	3.33	10.00
	J	3	3.67	11.00
	Total	6		

Test Statistics[b]

	Flange of the auricular implant	Middle portion of thread impression on the bone	End portion of the auricular implant
Mann-Whitney U	2.000	3.000	4.000
Wilcoxon W	8.000	9.000	10.000
Z	-1.091	-.655	-.218
Asymp. Sig. (2-tailed)	.275	.513	.827
Exact Sig. [2*(1-tailed Sig.)]	.400[a]	.700[a]	1.000[a]

a. Not corrected for ties.

b. Grouping Variable: SAMPLE

3MM CAUDAL PART T-TEST TABLE- 8

Group Statistics

	SAMPLE	N	Mean	Std. Deviation	Std. Error Mean
Flange of the auricular implant	G	3	.400867	.4953286	.2859781
	J	3	.276190	.6364660	.3674638
Middle portion of thread impression on the bone	G	3	.3698300	.50545122	.29182240
	J	3	.2004067	.06051010	.03493552
End portion of the auricular implant	G	3	.160700	.0476211	.0274940
	J	3	.189333	.0732006	.0422624

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Flange of the auricular implant	Equal variances assumed	.356	.583	.268	4	.802	.1246767	.4656320	-1.16812	1.4174783
	Equal variances not assumed			.268	3.772	.803	.1246767	.4656320	-1.19946	1.4488171
Middle portion of thread impression on the bone	Equal variances assumed	4.772	.094	.576	4	.595	.16942333	.29390611	-.646591	.98543752
	Equal variances not assumed			.576	2.057	.621	.16942333	.29390611	-1.06198	1.400831
End portion of the auricular implant	Equal variances assumed	.503	.517	-.568	4	.600	-.0286333	.0504186	-.1686178	.1113511
	Equal variances not assumed			-.568	3.436	.605	-.0286333	.0504186	-.1781681	.1209015

NPar Tests

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Mann-Whitney Test

Ranks

	SAMPLE	N	Mean Rank	Sum of Ranks
Flange of the auricular implant	G	3	3.67	11.00
	J	3	3.33	10.00
	Total	6		
Middle portion of thread impression on the bone	G	3	4.00	12.00
	J	3	3.00	9.00
	Total	6		
End portion of the auricular implant	G	3	2.67	8.00
	J	3	4.33	13.00
	Total	6		

Test Statistics [b]

	Flange of the auricular implant	Middle portion of thread impression on the bone	End portion of the auricular implant
Mann-Whitney U	4.000	3.000	2.000
Wilcoxon W	10.000	9.000	8.000
Z	-.218	-.655	-1.091
Asymp. Sig. (2-tailed)	.827	.513	.275
Exact Sig. [2*(1-tailed Sig.)]	1.000[a]	.700[a]	.400[a]

a. Not corrected for ties.

b. Grouping Variable: SAMPLE

4MM CRANIAL PART T-TEST- TABLE -9

Group Statistics

	SAMPLE	N	Mean	Std. Deviation	Std. Error Mean
Flange of the auricular implant	H	3	.172990	.5377368	.3104625
	K	3	1.332863	.9880177	.5704323
Middle portion of thread impression on the bone	H	3	.2587167	.44513136	.25699671
	K	3	.2571800	.36796846	.21244669
End portion of the auricular implant	H	3	.181303	.1341366	.0774438
	K	3	.118333	.0165630	.0095627

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Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Flange of the auricular implant	Equal variances assumed	1.374	.306	-1.786	4	.149	-1.1598733	.6494459	-2.96302	.6432776
	Equal variances not assumed			-1.786	3.089	.169	-1.1598733	.6494459	-3.19331	.8735664
Middle portion of thread impression on the bone	Equal variances assumed	.260	.637	.005	4	.997	.00153667	.33343801	-.924236	.92730899
	Equal variances not assumed			.005	3.863	.997	.00153667	.33343801	-.937299	.94037197
End portion of the auricular implant	Equal variances assumed	4.407	.104	.807	4	.465	.0629700	.0780320	-.1536815	.2796215
	Equal variances not assumed			.807	2.061	.502	.0629700	.0780320	-.2634332	.3893732

NPar Tests

Mann-Whitney Test

Ranks

	SAMPLE	N	Mean Rank	Sum of Ranks
Flange of the auricular implant	H	3	2.33	7.00
	K	3	4.67	14.00
	Total	6		
Middle portion of thread impression on the bone	H	3	3.67	11.00
	K	3	3.33	10.00
	Total	6		
End portion of the auricular implant	H	3	4.00	12.00
	K	3	3.00	9.00
	Total	6		

Test Statistics[b]

	Flange of the auricular implant	Middle portion of thread impression on the bone	End portion of the auricular implant
Mann-Whitney U	1.000	4.000	3.000
Wilcoxon W	7.000	10.000	9.000
Z	-1.528	-.218	-.655
Asymp. Sig. (2-tailed)	.127	.827	.513
Exact Sig. [2*(1-tailed Sig.)]	.200[a]	1.000[a]	.700[a]

a. Not corrected for ties.

b. Grouping Variable: SAMPLE

4MM CAUDAL PART T-TEST- TABLE-10

Group Statistics

	SAMPLE	N	Mean	Std. Deviation	Std. Error Mean
Flange of the auricular implant	H	3	.388910	.5215614	.3011236
	K	3	6.195533	4.4813867	2.5873298
Middle portion of thread impression on the bone	H	3	.3737600	.52752725	.30456800
	K	3	.3067467	.80612606	.46541710
End portion of the auricular implant	H	3	.168050	.1230164	.0710235
	K	3	.218400	.1205798	.0696168

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Flange of the auricular implant	Equal variances assumed	5.830	.073	-2.229	4	.090	-5.8066233	2.6047938	-13.0387	1.4254438
	Equal variances not assumed			-2.229	2.054	.152	-5.8066233	2.6047938	-16.7356	5.1223817
Middle portion of thread impression on the bone	Equal variances assumed	.493	.521	.120	4	.910	.06701333	.55621465	-1.47729	1.611313
	Equal variances not assumed			.120	3.447	.911	.06701333	.55621465	-1.57997	1.713992
End portion of the auricular implant	Equal variances assumed	.064	.813	-.506	4	.639	-.0503500	.0994527	-.3264749	.2257749
	Equal variances not assumed			-.506	3.998	.639	-.0503500	.0994527	-.3265185	.2258185

NPar Tests

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Mann-Whitney Test

Ranks

	SAMPLE	N	Mean Rank	Sum of Ranks
Flange of the auricular implant	H	3	2.00	6.00
	K	3	5.00	15.00
	Total	6		
Middle portion of thread impression on the bone	H	3	3.33	10.00
	K	3	3.67	11.00
	Total	6		
End portion of the auricular implant	H	3	3.00	9.00
	K	3	4.00	12.00
	Total	6		

Test Statistics[b]

	Flange of the auricular implant	Middle portion of thread impression on the bone	End portion of the auricular implant
Mann-Whitney U	.000	4.000	3.000
Wilcoxon W	6.000	10.000	9.000
Z	-1.964	-.218	-.655
Asymp. Sig. (2-tailed)	.050	.827	.513
Exact Sig. [2*(1-tailed Sig.)]	.100[a]	1.000[a]	.700[a]

a. Not corrected for ties.

b. Grouping Variable: SAMPLE

6 MM CRANIAL PART T-TEST- TABLE- 11

Group Statistics

	SAMPLE	N	Mean	Std. Deviation	Std. Error Mean
Flange of the auricular implant	I	3	.339657	.9114198	.5262085
	L	3	.344977	.4596799	.2653963
Middle portion of thread impression on the bone	I	3	.6652667	1.12646259	.65036348
	L	3	.0526200	.11866645	.06851210
End portion of the auricular implant	I	3	.158000	.0470319	.0271539
	L	3	.053267	.0263299	.0152016

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Flange of the auricular implant	Equal variances assumed	1.062	.361	-.009	4	.993	-.0053200	.5893476	-1.64161	1.6309712
	Equal variances not assumed			-.009	2.956	.993	-.0053200	.5893476	-1.89690	1.8862649
Middle portion of thread impression on the bone	Equal variances assumed	10.131	.033	.937	4	.402	.61264667	.65396220	-1.20304	2.428337
	Equal variances not assumed			.937	2.044	.446	.61264667	.65396220	-2.14339	3.368682
End portion of the auricular implant	Equal variances assumed	2.048	.226	3.366	4	.028	.1047333	.0311195	.0183318	.1911348
	Equal variances not assumed			3.366	3.142	.041	.1047333	.0311195	.0081739	.2012928

NPar Tests

Mann-Whitney Test

Ranks

	SAMPLE	N	Mean Rank	Sum of Ranks
Flange of the auricular implant	I	3	3.67	11.00
	L	3	3.33	10.00
	Total	6		
Middle portion of thread impression on the bone	I	3	4.00	12.00
	L	3	3.00	9.00
	Total	6		
End portion of the auricular implant	I	3	5.00	15.00
	L	3	2.00	6.00
	Total	6		

Test Statistics[b]

	Flange of the auricular implant	Middle portion of thread impression on the bone	End portion of the auricular implant
Mann-Whitney U	4.000	3.000	.000
Wilcoxon W	10.000	9.000	6.000
Z	-.218	-.655	-1.964
Asymp. Sig. (2-tailed)	.827	.513	.050
Exact Sig. [2*(1-tailed Sig.)]	1.000[a]	.700[a]	.100[a]

a. Not corrected for ties.

b. Grouping Variable: SAMPLE

6mm caudal part T-Test- table-12

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Flange of the auricular implant	Equal variances assumed	11.214	.029	1.256	4	.277	3.2512733	2.5884762	-3.93549	10.43804
	Equal variances not assumed			1.256	2.092	.331	3.2512733	2.5884762	-7.43113	13.93368
Middle portion of thread impression on the bone	Equal variances assumed	13.438	.021	1.629	4	.179	1.3464800	.82675281	-.948954	3.641914
	Equal variances not assumed			1.629	2.000	.245	1.3464800	.82675281	-2.21013	4.903087
End portion of the auricular implant	Equal variances assumed	1.089	.356	-2.470	4	.069	-.1994333	.0807549	-.4236449	.0247782
	Equal variances not assumed			-2.470	2.990	.090	-.1994333	.0807549	-.4569400	.0580733

NPar Tests

Mann-Whitney Test

Ranks

	SAMPLE	N	Mean Rank	Sum of Ranks
Flange of the auricular implant	I	3	4.67	14.00
	L	3	2.33	7.00
	Total	6		
Middle portion of thread impression on the bone	I	3	4.00	12.00
	L	3	3.00	9.00
	Total	6		
End portion of the auricular implant	I	3	2.33	7.00
	L	3	4.67	14.00
	Total	6		

Test Statistics[b]

	Flange of the auricular implant	Middle portion of thread impression on the bone	End portion of the auricular implant
Mann-Whitney U	1.000	3.000	1.000
Wilcoxon W	7.000	9.000	7.000
Z	-1.528	-.655	-1.528
Asymp. Sig. (2-tailed)	.127	.513	.127
Exact Sig. [2*(1-tailed Sig.)]	.200[a]	.700[a]	.200[a]

a. Not corrected for ties.

b. Grouping Variable: SAMPLE

T-TEST- TABLE-13

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
SITE1	V - SHAPE 3 mm	3	32.67	1.155	.667
	BUTTRESS SHAPE 3 mm	3	66.33	1.155	.667
SITE2	V - SHAPE 3 mm	3	44.67	2.309	1.333
	BUTTRESS SHAPE 3 mm	3	62.33	1.528	.882
SITE3	V - SHAPE 3 mm	3	44.67	2.309	1.333
	BUTTRESS SHAPE 3 mm	3	57.67	1.155	.667
SITE4	V - SHAPE 3 mm	3	40.33	1.155	.667
	BUTTRESS SHAPE 3 mm	3	65.67	3.512	2.028
SITE5	V - SHAPE 3 mm	3	39.00	2.000	1.155
	BUTTRESS SHAPE 3 mm	3	57.67	1.155	.667

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SITE1	Equal variances assumed	.000	1.000	-35.709	4	.000	-33.667	.943	-36.284	-31.049
	Equal variances not assumed			-35.709	4.000	.000	-33.667	.943	-36.284	-31.049
SITE2	Equal variances assumed	1.241	.328	-11.051	4	.000	-17.667	1.599	-22.105	-13.228
	Equal variances not assumed			-11.051	3.469	.001	-17.667	1.599	-22.386	-12.947
SITE3	Equal variances assumed	3.200	.148	-8.721	4	.001	-13.000	1.491	-17.139	-8.861
	Equal variances not assumed			-8.721	2.941	.003	-13.000	1.491	-17.798	-8.202
SITE4	Equal variances assumed	2.063	.224	-11.869	4	.000	-25.333	2.134	-31.259	-19.407
	Equal variances not assumed			-11.869	2.427	.003	-25.333	2.134	-33.129	-17.538
SITE5	Equal variances assumed	.400	.561	-14.000	4	.000	-18.667	1.333	-22.369	-14.965
	Equal variances not assumed			-14.000	3.200	.001	-18.667	1.333	-22.764	-14.570

NPar Tests

Mann-Whitney Test

Student's' test used to assess the significant difference between two group of implants

Ranks

	GROUP	N	Mean Rank	Sum of Ranks
SITE1	V - SHAPE 3 mm	3	2.00	6.00
	BUTTRESS SHAPE 3 mm	3	5.00	15.00
	Total	6		
SITE2	V - SHAPE 3 mm	3	2.00	6.00
	BUTTRESS SHAPE 3 mm	3	5.00	15.00
	Total	6		
SITE3	V - SHAPE 3 mm	3	2.00	6.00
	BUTTRESS SHAPE 3 mm	3	5.00	15.00
	Total	6		
SITE4	V - SHAPE 3 mm	3	2.00	6.00
	BUTTRESS SHAPE 3 mm	3	5.00	15.00
	Total	6		
SITE5	V - SHAPE 3 mm	3	2.00	6.00
	BUTTRESS SHAPE 3 mm	3	5.00	15.00
	Total	6		

Test Statistics[b]

	SITE1	SITE2	SITE3	SITE4	SITE5
Mann-Whitney U	.000	.000	.000	.000	.000
Wilcoxon W	6.000	6.000	6.000	6.000	6.000
Z	-2.023	-1.993	-2.023	-1.993	-1.993
Asymp. Sig. (2-tailed)	.043	.046	.043	.046	.046
Exact Sig. [2*(1-tailed Sig.)]	.100[a]	.100[a]	.100[a]	.100[a]	.100[a]

a. Not corrected for ties.

b. Grouping Variable: GROUP

DISCUSSION

DISCUSSIONS

The Success of Osseointegrated implant depends upon the mechanical loading. The way in which load from the implant is transferred to the hard tissue provide the stimulus that results in either remodeling or modeling. If the strains around the bone are beyond the physiologic range, then failure of the bone and or bone-implant interfaces occurs[41]. This situation holds good both for Intra oral and Extra-oral implants.

Stress distributed to the implant depends upon various factors such as design of the implant, the type of bone and the amount of force offered by the prosthesis. This study evaluates the stress distribution in the temporal region of craniofacial auricular implant used to retain auricular prosthesis.

Craniofacial auricular implants are commercially available in various lengths with flanges of 3mm, 4mm and 6mm respectively. Commercially available craniofacial auricular implants are marketed by (A) Branemark (Noble Biocare AB, Sweden) (B) Bud (Bud industries NY) (C) IMZ (Friatec AG, Germany) (D) Southern Implants (Irene, South Africa).

Craniofacial auricular implant marketed by Southern implant was taken as a control group because of the ease of availability in India. The implant used for this study was V-shape thread design IE3 with the length of 3mm and diameter of 3.75mm respectively.

Craniofacial auricular implants are very costly and cannot be afforded by common man in India. Hence an approach was made to develop indigenous implant for craniofacial auricular application. Titanium is available in Grade I, Grade II, Grade III and Grade IV of which Grade II and Grade IV are generally used for making implants. Grade II Titanium was used to make indigenous craniofacial auricular implant with Buttress shape thread design with the length of 3mm and diameter of 3.75mm respectively.

Thread shapes in dental implant designs can be Square-shape, V-shape and buttress-shape. In conventional engineering applications, the **V-shape thread is called a "fixture"** and is primarily used for fixturing metal parts together. **The buttress thread shape** is optimized for **pullout load**s. Dental implant applications dictate the need for a thread shape optimized for long-term function that is load transmission and intrusive the opposite of pullout load direction[43].

Design of thread is very important factor because it is responsible for shear component of force in the implant. It is a known that bone is 65% weaker in shear load. Shear loading is the most detrimental loading profile for bone.

Hence for craniofacial auricular implant, V-shape thread design was purchased from Southern Implant, South Africa and Buttress-shape thread was made indigenously.

Farah JW, Craig, created history by bringing Finite element method study in Dentistry for the first time, proving its efficiency to be better than photoelatic study in terms of easy modeling and more defined stress analysis[13].

Lucie Himmlova et al[44], evaluated the influence of implant length and diameter on stress distribution using Finite element analysis for Intra-oral implants.

Lai Hc et al,[30] evaluated the three dimensional FEM analysis of stress distribution around dental implants to estimate the influence of the length.

On the other hand **little work** has been reported on the differences **related to design, loading or bone configurations typical of craniofacial osseointegrated implant sites**. Literature review of Finite element analysis in craniofacial implant goes back to **1997** done by **Victor del valle et al**, after which, this area is less explored.

Victor del Valle et al, [5] evaluated the stress distribution that occurs in the region surrounding craniofacial osseointegrated implants using Finite element analysis.

This study was based on **flange design** in relation to stress distribution but the **importance of thread shape design and the length** of the implant on stress distribution **have not been studied**.

Hence it was decided to conduct a study on stress distribution that occurs in the temporal bone region surrounding craniofacial auricular implant with different implant thread shape design of varying length and constant diameter using Finite element analysis.

In the previous studies, numerical model was generated where bone was considered to be isotropic and homogenous with the character of cortical bone and by imparting the Poison ratio, Young modulus of elasticity and density of the material[7].

In this study the method of scanning to produce the 3Dcloud point to produce a solid model of the temporal bone region considered superior when compared to the numerical model because scanning method is considered to be precise and accurate[9].

To measure the thread profile of the implant, the optical comparator was used. For measuring the thread profile of an implant of 3.75mm diameter, a magnification level of 10x was sufficient. The optical comparator had a magnification range of up to 100x. Therefore the thread profile of the implant was accurately obtained at a magnification of 10x using the optical comparator.

In Finite element technique, the programmed software ANSYS conduct 3D analysis. The results of which are presented in color graphs format to know the stress and strain pattern development.

The effect of stress and strain distribution in the temporal region surrounding craniofacial auricular implants are evaluated and compared in both cranial and caudal site region of both V-shape thread design and Buttress-shape thread design of varying length of 3mm, 4mm, and 6mm respectively with constant diameter 3.75mm.

Two loading condition, one vertical load of 10N and second a moment of 100 Nmm was applied to the centre of the craniofacial auricular implants individually and to the center of gold bar which connects the two implants.

Literature review on craniofacial implants reveals that this study has never been performed till now.

Per-Ingvar Branemark[4]studied on biomechanical model of the case, to predict the loadings on two implants when a test load of magnitude 10N is applied in the negative Y-direction at a particular point on the framework. Consideration was made in a horizontal load in the plane of the prosthetic bar, perpendicular to the long axes of the two implants in the bone. 10N was found to be nominal test load. **No data are available on actual forces on the type of prosthesis in vivo.**

The **mean stress** values of craniofacial auricular implant in **3mm** length and 3.75mm diameter in the **flange area** of the auricular implant was found to be **statistically significant p value < 0.05**in both V-shape thread design and Buttress-shape thread design.

The mean stress values of craniofacial auricular implant with **4mm** and **6mm,** length and 3.75mm diameter in the middle portion of the implant and end portion of the implant in both V-shape thread design and Buttress-shape thread design is **statistically insignificant** by which the stress distribution in these areas are found to be minimal.

This infers that **increase in the length of the craniofacial auricular implant does not affect the diameter of the flange**. The stresses are concentrated only in the flange area and the tip of the flange which touches the first thread of the implant.

The **mean stress values** of craniofacial auricular implant with **bar connected** together in 3mm, 4mm and 6mm length with 3.75mm diameter in both V-shape thread design and Buttress-shape thread design is **statistically insignificant.**

The **stress distribution** found to be **better** in **buttress shaped threaded** implants irrespective of the length 4mm and 6mm. Most of the stress concentration was taken up by the flange and the subsequent thread. This could be related to the increased surface area of the thread design in buttress shape implants when compared to V-shape thread design.

In this study shows, from a **biomechanical standpoint**, buttress shape thread design in implants allows engagement of a maximal amount of bone, and improved distribution of stress in the surrounding bone. This also allows for the application of higher torque in the placement of prosthetic components.

The **buttress shape thread** design has known advantages of providing more bone to implant contact, bicortical engagement, and reduction in abutment stresses and strain. Therefore, more contact area provides increased initial stability and reduces the stresses.

Kim WT, Cha YF et al[45], evaluated three thread type implants of similar diameter and length, thread number, and depth with a three-dimensional finite element analysis. The overall stresses and shear stresses are compared. The square-thread implant has less overall and less shear stress. The V-shape thread and reverse buttress shape are similar.

Chun et al[46], also used Finite element analysis to evaluate design parameters of osteointegrated dental implants. They have concluded the square-thread design has a beneficial shape for loading compared with other thread designs.

The study further follows the determination of the **primary stability** in the **fresh goat maxilla** by placing the V-shape thread and Buttress-shape thread design of 3mm length and 3.75mm diameter at varying sites.

Stability is essential for optimal implant function. Primary stability is obtained by mechanical fixation of the implant with bone, and this is one of the basic conditions for osseointegration. It is related with implant surface area, geometry, length, contact area and between bone and implant[10].

Osseointegration is basically a histological concept, and only partially clinical and radiological. Several studies have shown that this process consists of a gradual increase in the amount of bone in direct contact with the implant surface over time. The quantity and quality of bone formed at the interface is of utmost importance in determining the holding power of an implant.

The stability of osseointegrated, temporal bone implants was investigated by **Tjellstrom**[47] et al and **Yamanaka et** al[48].

Jae-Min-Kim[11] evaluated the implant stability in humans using Resonance frequency analysis, among various implant systems available in the market.

Ju- Hee park[6], assessed the primary stability of various thread design on the initial stability of taper implants in swine ribs.

A non-invasive method to measure implant stability was described by **Meredith et al**. and measures the resonance frequency and damping of the transducer.

In this study, Resonance frequency analysis was used, to evaluate the stability of craniofacial auricular implant in the fresh goat maxilla. It determines the implant stability with an implant stability meter. A probe emits magnetic pulses to a small magnet at the top of an abutment which is attached to the implant. The abutment starts to vibrate, the probe listens to the tone and translates it to an Implant stability quotient value.

The mean value for V-shape thread design is 2 and Buttress-shape thread design shows a value of 5. This infers that primary stability in Buttress shape thread is more stable than V-shape thread design.

The increased primary stability exhibited by the buttress shape thread design craniofacial auricular implant could be attributed to increased surface area of this particular design when compared to v-shape thread design implant.

Potential applications for resonance frequency analysis are not only as a research tool but also as a clinical aid in diagnosis in near future. However, it is only a combination of techniques that can lead to a complete understanding of the host response to the implant placement.

The efficacy of this study under varied clinical condition also needs to be studied to enhance the results.

SUMMARY & CONCLUSION

SUMMARY AND CONCLUSION

This study was done to evaluate the thread design of conventional implant and indigenous implant in implant retained auricular prosthesis- its implant thread shape, diameter and length on stress distribution using Finite element analysis. This study follows to determine the primary stability of the craniofacial auricular implant in the fresh goat maxilla using Resonance frequency analysis method.

Both the groups were loaded with a force of vertical load of 10N and a second moment of 100 Nmm applied in the centre of the cranial and caudal part in the temporal region independely and with two implants connected by gold casting bar. The results were analyzed and interpreted using ANSYS Software. The data's was obtained, tabulated and statistical analysis was done.

Within the limitations of this study, supports the following that FEA has been used extensively in the prediction of performance of craniofacial auricular implant systems. In the modeling, some assumptions greatly affect the predictive accuracy of the FEA model. These include assumptions involving model geometry, material properties, applied boundary conditions, and the bone-implant interface. To achieve more realistic models, advance

3D White light scanner can be used to model bone geometry in greater details. In addition, modeling of the bone-implant interface should incorporate the actual osseointegration contact area in cortical bone as well as 3-dimensional bone contact.

Load transmission and resultant stress distribution at the bone-implant interface and with two implants connected by gold bar has been the subject of FEA studies. Factors that influence load transfer include the type of loading, implant and prosthesis material properties, implant length, implant diameter, implant thread shape and nature of the bone-implant interface.

Of these biomechanical factors, implant length, diameter and shape can be modified easily in the implant design. In Finite element analysis, with the increase in craniofacial implant length in Group I and Group II from 3mm, 4mm, and 6mm with constant diameter 3.75mm for V-shape thread design and Buttress shape thread design implant, resulted in reduction in the stress for Buttress shape thread. There was no effect on diameter of the flange when the length of the craniofacial implant increased. When two implants connected by bar, the stress distribution is very minimal.

By Resonance frequency analysis, in fresh goat skull, the readings were found to be statistically higher ISQ values in buttress-shape thread when compared to V-shape thread. RFA is related to the stability of the implant-bone interface. The time and bone quality interaction has significant influence on ISQ values. More studies are required about RFA in clinical case of craniofacial auricular implant systems.

Future scope needs to be on research and development coupled with controlled, prospective clinical studies to guide the clinician in near future. This studies further needs to be studied clinically.

BIBLIOGRAPHY

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1. Akagawa Y, Sato Y, Teixeira E R, Shindoi N & Wadamoto M. A mimic osseointegrated implant model for three-dimensional finite element analysis: Journal of Oral Rehabilitation, 2003, 30, 41-45.
2. Allahyar Geramy, Steven M Morgano. Finite element analysis of three designs of an implant supported molar crown: Journal of Prosthet Dent., 2004, 92(5), 434-440.
3. Arthur M Rodriguez, Steven A Aquilino, Peter S Lund. Cantilever and Implant Biomechanics: A Review of the Literature, Part 2 : Journal of Prosthodontics, 1994, 3(2), 114-118.
4. Atilla Sertgoz, Sungur Guvener. Finite element analysis of the effect of cantilever and implant length on stress distribution in an implant supported fixed prosthesis: J Prosthet Dent, 1996, 76(2), 165-169.
5. Bengt Kasemo. Jukka Lausmaa. Biomaterial and Implant Surfaces: A Surface Science Approach: Quintessence Pub. Co., 1988, 3(4(247-259), 1-7.

6. Borchers L, Reichart P. Three dimensional Stress Distribution around a Dental Implant at Different Stages of Interface Development: J.Dent Res. 1983, 62(2), 155-159.

7. Carl E Misch, Francine Dietsh Misch, John Hoar, George Beck, Ray Hazen, Craig M Misch. A Bone quality based implant system: First year of prosthetic loading: Journal of Oral Implantology, 1999, XXV,185-197.

8. Carl E. Misch. Contemporary Implant Dentistry , 3/e,2008;pg 209.

9. Carl E. Misch. Contemporary Implant Dentistry. 2/e,1999;pg 336

10. Chol AH, Ben Nissan B, Conway R C. Three dimensional modeling and finite element analysis of the human mandible during clenching: Australian Dental Journal: 2005, 50(1), 42-48.

11. Chun H. S., Cheong S. Y., Han J. H. Et al. Evaluation of design parameters of osseointegrated dental implants using fiinite element analysis. J Oral Rehabil 2002;29:565-574.

12. Craig M Misch, Ismail Y H. Finite Element Stress Analysis of Tooth to Implant Fixed Partial Denture Designs: Journal of Prosthodontics, 1993,2(2), 83-92.

13. Daniel H, DeTolla, Sebastiano Andreana, Abani Patra, Robert Buhite, Brandon Comella. The Role of the finite element model in dental implants:Journal of Oral Implantology, 2000, XXVI (2), 209-218.

14. David C Holmes, Chris R Hagaman, Steven A Aquilino. Deflection of Superstructure and Stress Concentration in the IMZ Implant System: Int. J Prosthodont, 1994, 7(3), 239-246.

15. Dincer Bozkaya, Sinan Muftu. Mechanics of the tapered interference fit in dental implants: Journal of Biomechanics, 2003, 1649-1658.

16. Eric P Holmgren, Robert J Seckinger, Leslie M Kilgren, Francis Mante. Evaluating Parameters of Osseointegrated Dental Implants using Finite Element Analysis – A Two Dimensional Comparative Study Examining the Effects of Implant Diameter, Implant Shape, and Load Direction : Journal of Oral Implantology, 1998, XXIV(2), 80-88.

17. Farah J W, Craig R G. Finite Element Stress Analysis of a Restored Axisymmetric First Molar: J.Dent. Res. 1974, 53(4), 859-866.

18. Goran Bergkvist, Kjell Simonsson, Kristofer Rydberg, Fredrik Johansson, Tore Derand. A Finite Element Analysis of Stress Distribution in Bone Tissue Surrounding Uncoupled or Splinted Dental Implants: Clin. Implant Dististry and Related Research, 2008, 10(1), 40-46.
19. Hung Chan Kao, Yih Wen Gung, Tai Foong Chung, Ming Lun Hsu, Dr.Med Dent. The influence of Abutment Angulation on Micromotion Level for Immediately Loaded Dental Implants: A 3-D Finite Element Analysis, 2008.
20. Jae-Min Kim et al. A Comparison of the Implant Stability among Various Implant Systems: Clinical Study. J Adv Prosthodont 2009; 1:31- 36.
21. John Beumer III. Maxillofacial Rehabilitation- Prosthodontic and Surgical Considerations; 1996, pg 377.
22. Ju-Hee Park et al. The Effect of various Thread Designs on Initial Stability of Taper Implants . J Adv Prosthodont 2009;1:19-25.
23. Kim W. T., Cha Y. F., Oh S. J. Et al. The three dimensional finite analysis of stress according to implant thread design under the axial load. Korean J Oral Surg,2001;27:3-8.

24. Lai H C, Xiong H G, Xue M, Yang C Y, Zhang B W. Three dimensional FEM analysis of stress distribution around dental implants to estimate the influence of the length: Journal of Oral Implantology, 2004, 30(4), 223-33.
25. Lekholm U, Dr. Odont., Clinical Procedures for treatment with osseointegrated dental implants, 1983, 50(1), 116-120.
26. Li Shi, Beng, Haiyan Li Beng, Alex S L Fox, Beng, Ceng, Cemal Ucer, Hugh Devlin, Keith Horner. Shape optimization of Dental Implants: Journal of Oral & Maxillofacial Implants, 2007, 22, 911-920.
27. Lucie Himmlova, Tatjana Dostalova, Aloice Kacowsky et al. Influence of implant length and diameter on stress distribution: A finite element analysis. J prosth dent, 2004;91:20-25.
28. Malevez Ch., Hermans M, Daelemans. Marginal bone levels at Branemark system implants used for single tooth restoration. The influence of implant design and anatomical region: Clin Oral Impl Res., 1996, 7, 162-169.

29. Meijer H J A, Kuiper J H, Starmans F J M. Stress distribution around dental implants: Influence of superstructure, length of implants, and height of mandible: Journal of Prosthet Dent. 1992, 68, 96-102.
30. Meredith N, Alleyne D, Cawley P. Quantitative Determination of the Stability of the Implant-tissue Interface using Resonance Frequency Analysis. Clin Oral Implants Res 1996;7:261.
31. N. L. Clelland et al. Three Dimensional Finite Element Analysis in and around Screw-Vent Implants. Int J Oral Maxillofac Implants 1991;6:391-398.
32. Nancy L Clelland, June K Lee, Oliver C, Bimbenet M S, Amos Gilat. Use of an Axisymmetric Finite Element Method to compare maxillary bone variables for a loaded implant: Journal of Prosthodontics, 1993, 2(3),183-189.
33. Nancy L Clelland, June K Lee, Olivier C Bimbenet, William A Brantley. A Three Dimensional Finite Element Stress Analysis of Angled Abutments for an Implant Placed in the Anterior Maxilla: J Prosthod, 1995, 4, 95-100.
34. Nitin S Gokhle et al. Practical Finite Element Analysis, 1/e,2008;pg 03.

35. Per Ingvar Branemark, Osseointegration and its experimental background: Journal of Prosthetic Dentistry, 1983, 50(3), 399-410.
36. Per-Ingvar Branemark and Dan E. Tolman. Osseointegration in Craniofacial Reconstruction 1998;pg 03.
37. Rieger M R, Adams W K, Kinzel G L. A finite element survey of eleven endosseous implants: J Prosthet Dent, 1990, 63(4), 457-465.
38. Rieger M R, Fareed K, Adams W K, Tanquist R.A. Bone Stress distribution for three endosseous implants: Journal of Prosthetic Dentistry, 1989,223-228.
39. Rieger M R, Mayberry M, Brose M.O. Finite element analysis of six endosseous implants: Journal of Prosthet Dent. 1990, 63(6), 671-676.
40. Rieger M R. Finite Element Stress Analysis of Root Form Implants, JOI,1988, XIV (4), 472-484.
41. Roxana Stegaroiu, Takahiro Sato, Haruka Kusakari. Influence of Restoration Type on Stress Distribution in Bone Around Implants: A Three-Dimensional Finite Element Analysis. Int J Oral Maxillofac Implants 1998;13:82-90

42. Sato Y, Wadamoto M, Tsuga K, Teixeira E R. The effectiveness of element downsizing on a three dimensional finite element model of bone trabeculae in implant biomechanics: Journal of Oral Rehabilitation, 1999, 26,288-291.
43. Tan et al. Application of FEA in Implant Dentistry. A review of literature J Prosthet Dent 2001;85:585-598.
44. Thomas D Taylor, John R Agar. Twenty years of progress in implant prosthodontics: Journal of Prosthet Dent., 2002, 89-95.
45. Tjellstrom A, Jacobsson M, Albrektsson T. Removal torque of osseointegrated craniofacial implants: A clinical study. Int J Oral Maxillofac Implants,1988;3:287
46. Victor Del Valle et al. Craniofacial Osseointegrated Implant-Induced Strain Distribution: A Numerical study. Int J Oral Maxillofac Implants 1997;12:200-210.
47. Victor Del Valle et al. Mechanical Evaluation of Craniofacial Osseointegration Retention Systems. Int J Oral Maxillofac Implants 1995;10:491-498.

48. Yamanaka E, Tjellstrom A, Jacobsson M, Albrektsson T. Long term observation on removal torque of directly bone-anchored implants in man. In Yanigihara N, Suzuki Z. I(eds): Transplants and Implants in Otology. Amsterdam: Kugler Publications;1992:245