International Journal of Analytical, Experimental and Finite Element Analysis (IJAEFEA), Issue. 2, Vol. 6, May 2019
e-ISSN: 2394-5141, p-ISSN: 2394-5133, pp 99 - 105
DOI: 10.26706/IJAEFEA.2.6.20190416

Failure Analysis of Hexagonal Headed Screw to Clamp Orthodontic Clip

Pranit Dhole[1],
dpranit07@gmail.com

Saurabh Khaire[2],
khairesaurabh@gmail.com

Machindra Adsul[3],
adsulmac@gmail.com

Gaurav Bhor[4]
gaurav.bhor97@gmail.com

Students, Department Of Mechanical Engineering, JSPM Narhe Technical Campus, Pune, India

***Abstract*—The human teeth function is that to mechanically breakdown items of food by cutting and crushing them in preparation for swallowing and digesting. Tooth Development is complex process by which the teeth form from embryonic cells, grow into mouth. By significant amount of research in this field, it is widely accepted that there is most of factor within tissues that is necessary for development of teeth. Orthodontic dental implants have become a widely accepted treatment option for both partially and completely for lack amount of teeth's in patients' mouth. The clinical use of miniscrew anchorage includes some risks. Screw fracture might be one of the most undesirable side effects in clinical use of miniscrew anchorage. Orthodontic Implant Screw of Organization S.K. Surgical is undergoing failure at time of insertion. Failure of Implant Screw in jaw of patient is causing major problems like surgery for removal, long healing period of jaw, time and money wastage, loss of Reputation.**

Index terms: *Human Teeth, Tooth Development Process, Miniscrew Anchorage, Failure of Implant Screw.*

I. Introduction

The human teeth function is to mechanically breakdown various types of food items by cutting and crushing them in preparation for swallowing and digesting. There are four types of teeth's human have: incisors, canines, premolars and molars, which each have specific function.

Tooth Development is a complex process by which teeth form from embryonic cells, grow and erupt into mouth. By significant amount of research, it is widely accepted that there is factor within tissues that is necessary for development of teeth. This factor varies from person to person. Due to variation, in some cases misaligned teeth are erupted in mouth. A misaligned tooth causes problems to person. Hence it is necessary to make them aligned. Orthodontic implants are used in case of treatment of misaligned teeth.

Orthodontic dental implants have been become a widely accepted better treatment option for both partially and completely edentulous patients. The physiological basis for success of dental implants lies in the unique bone reaction to titanium. A recent review found that there is not enough evidence to demonstrate superiority of any particular type of implant or an implant system.

Miniscrew anchorage has been greatly expanded that limit of clinical orthodontics. Even without patient compliance, miniscrews can be provide stationary anchorages for various tooth movements and even make it possible to move the tooth in directions which have been impossible with traditional orthodontic mechanics. On the other hand this happens in not only the placement but also the removal. A lot of factors are suggested to relate with screw failure, but screw-root proximity and mandible are considered as two common factors. Damages of soft tissues are temporary in most cases, but damages of hard tissues are irreversible and should be avoided.

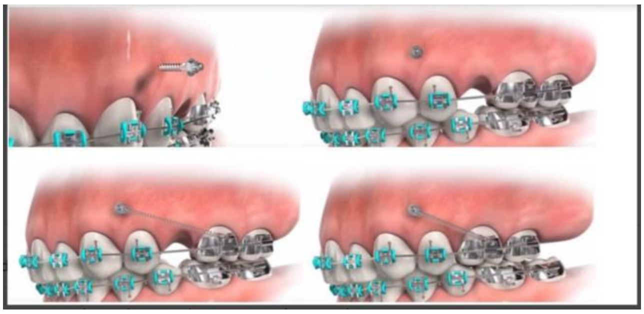

Fig 1. Anchorage Used for Treatment

Anchorage control during tooth movement is one of the main factors for ensuring successful orthodontic treatment. Anchorage can be defined as the resistance that a tooth or a group of teeth offer when they are subjected to a force. The aim of orthodontic treatment is to maintain sufficient anchorage control to create appropriate force systems that provide the desired treatment effects. Currently, clinicians mostly prefer to use miniscrews for combined orthodontic treatment. Despite the high success rate of miniplates, their invasive placement procedures require an oral surgeon and the associated high costs of such a procedure overshadow t heir use in terms of anchorage. Miniscrews, however, are available in favorable sizes, have relatively lower costs and are simple to insert and remove; therefore, they can be easily placed by an orthodontist with minimal tissue invasion. Miniscrews obtain their stability mainly from mechanical retention in the bone, so they can be loaded immediately after placement. In the literature, there is no general agreement about the terminology used; this varies between 'miniscrews

Orthodontic Implant Screw of Organization S.K. Surgical is undergoing failure at time of insertion. Failure of Implant Screw in jaw of patient is causing major problems like surgery for removal, long healing period of jaw, time and money wastage, loss of Reputation.

II. Dimensional Verification

A. Profile Projector

A profile projector is an optical instrument that can be used for measuring the dimensions. It is a useful item in a small parts machine shop or production line for the quality control inspection team.

1) Selection Method for Profile Projector
2) Select screen size
3) Choose magnification
4) Select the appropriate work table and accessories.
5) Select the appropriate precision

B. Digital Caliper

The Digital Caliper (sometimes incorrectly called the Digital Vernier Caliper) is a precision instrument that can be used to measure internal and external distances extremely accurately. The example shown below is a digital caliper as the distances/measurements, are read from a LCD display. The most important parts have b labeled Also; the digital version requires a small battery whereas the manual version does not need any source. Digital calipers are easier to use as the measurement is clearly displayed and also, by pressing the inch/mm button the distance can be read as metric or imperial.

The display is turned on with the on/off button. The external jaws should then be brought together until they touch and the zero button should be pressed. The digital caliper can then be used to measure distances. Always go through this procedure when turning on the display for the first time.

Fig 2. Measurement on Digital Caliper

TABLE 1

MEASURED DIMENSIONS OF SCREW

Sr.No.	Particular	Symbol	Unit	Values
1	Pitch	p	mm	0.81
2	Mean Diameter	Dmean	mm	1.5
3	Outer Diameter	Dout	mm	2
4	Inner Diameter	Din	mm	1.3
5	Length	L	mm	8

III. FINITE ELEMENT ANALYSIS

Finite element analysis is an effective tool used to evaluate the biomechanical characteristics of different types of dental implants.

Thickness of human jaw is mainly divided into three layers named as –

1. Cortical bone
2. Cancelleous bone
3. Gum

A. *Modeling of Hexagonal Headed Screw*

CAD Model hexagonal headed screw is prepared as problem occurring screw dimensions given from organization.

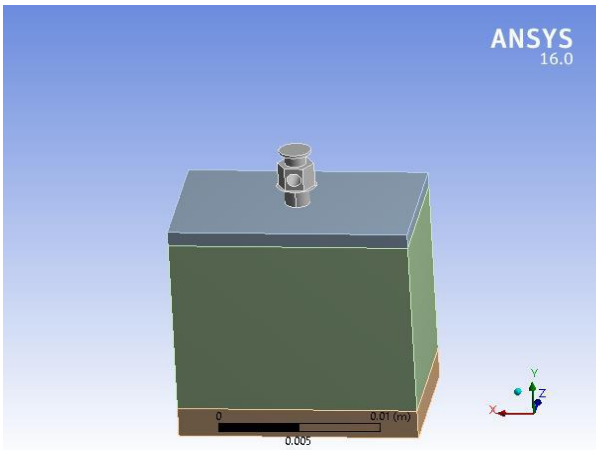

Fig 3. Cad Model of Screw with Jaw

TABLE 2

DIMENSIONS OF EXISTING SCREW

Sr.No.	particular	symbol	Unit	Values
1	Pitch	p	mm	0.81
2	Mean Diameter	Dmean	mm	1.5
3	Outer Diameter	Dout	mm	2
4	Inner Diameter	Din	mm	1.3

B. *Analysis of Existing Hexagonal Headed Screw*

To reduce the failure of hexagonal headed screw, an analysis of existing screw is carried out using finite element analysis. The CAD Model of existing screw is prepared as per the dimensions received from organization and verified using experimental method.

TABLE 3

DIMENSIONS OF EXISTING HEXAGONAL HEADED SCREW

Sr. No.	Particular	Symbol	Unit	Values
1	Pitch	p	mm	0.82
2	Mean Diameter	Dmean	mm	1.5
3	Outer Dia.	Dout	mm	1.56
4	Inner Dia.	Din	mm	0.9
5	Length	L	mm	10.92

The strength of material Ti6Al4V is as follows:

Allowable Yield Strength = 880 MPa

Maximum shear strength = 0.5 × Yield strength = 440 MPa

Maximum Principal Stress In Model-1= 883.7 MPa

Fig 4. Deformation of Existing Screw

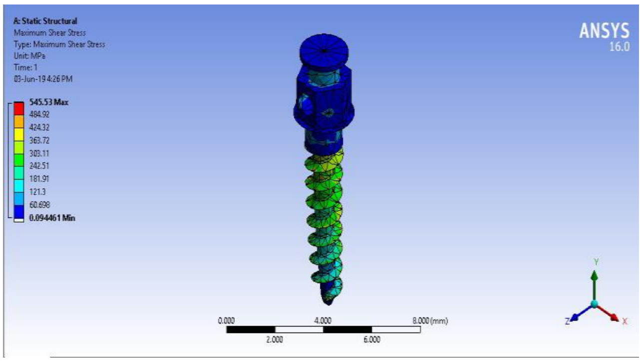

Fig 5. Maximum Shear Stress of Existing Model

Based on the finite element modeling and analytical calculation the force of 100N and moment of 50 N-mm is applied as boundary condition on the thread and screw is restricted to rotate at its head. The model is meshed with solid 187 tetrahedral element due to irregularities in modeling. The results obtained in postprocessing as deformation, maximum shear stress and maximum principal stress are given in table 4. From the valued it is observed that the maximum shear stress and maximum principal stress exceeds the value of shear strength and yield strength of material. Hence it can be concluded that the screw can not bear load acting due to resistance of cortical and cancellous bone of jaws and hence failed.

TABLE 4

ANALYSIS OF EXISTING SCREW

Sr. No	**Particular**	**Value**
1	Deformation	0.060077mm
2	Maximum shear stress	545.53Mpa
3	Maximum principal stress	883 MPa

IV. PROPOSED MODIFICATIONS

1. *Increasing Pitch and Core diameter of Hexagonal headed screw*

As per the results discussed above, over existing hexagonal headed screw, the pitch and core diameter is required to increase by 0.2 mm i.e. 1.1 mm. the change in dimensions are shown in table 5 for which the CAD model is prepared for the finite element analysis. Again the same load of 100N and moment of 50N-mm is applied as boundary condition and screw is fixed at its head.

TABLE.5

DIMENSIONS OF MODIFICATION 1

Sr. No.	Particular	Symbol	Unit	Values
1	Pitch	P	mm	1.1
2	Mean Diameter	Dmean	mm	1.5
3	Outer Dia.	Dout	mm	1.56
4	Inner Dia.	Din	mm	1.1
5	Length	L	mm	10.92

The strength of material Ti6Al4V is as follows:

Allowable Yield Strength = 880 MPa

Maximum shear strength = 0.5 × Yield strength = 440 MPa

Maximum Principal Stress In Model-1= 883.7 MPa

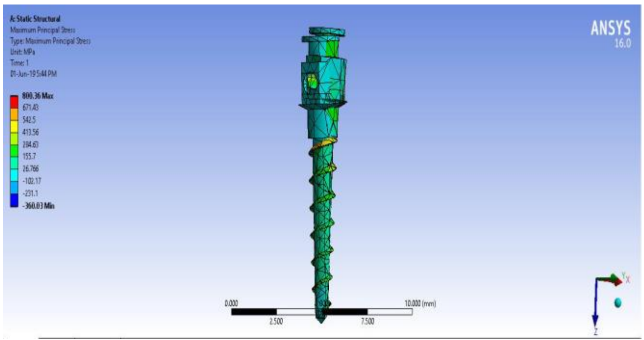

Fig 6. Maximum Principal Stress Analysis Of Modification 1

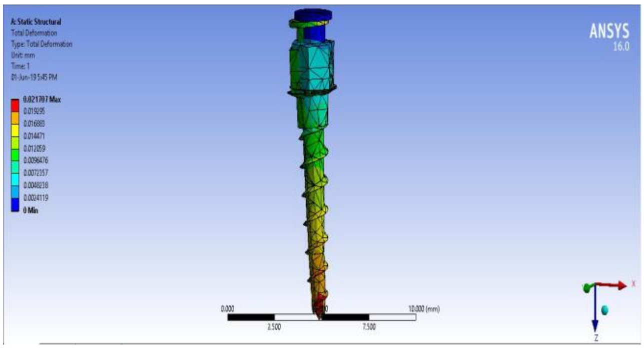

Fig 7. Total Deformation Of Modification 1

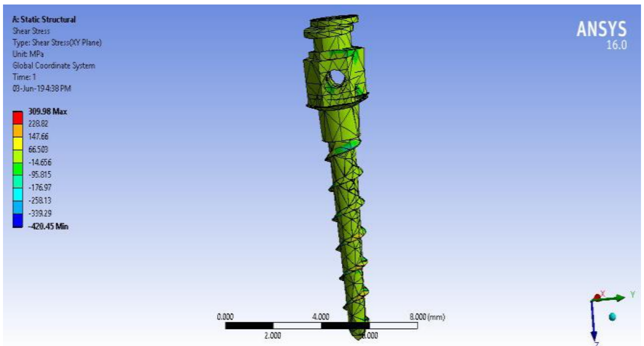

Fig 8. Maximum Shear Stress of Modification 1

The results of obtained are given in table 6. From the analysis it is observed that the stresses are reduced at some extent such as maximum principal stress of 803 MPa and maximum shear stress of 309.98MPa which are nearer to yield and shear strength of material and hence this modifications cannot recommended.

TABLE 6

ANALYSIS OF MODIFICATION 1

Sr. No	Particular	Value
1	Deformation	0.0210707mm
2	Maximum shear stress	309.98MPa
3	Maximum principal stress	800.36MPa

2. Increasing Core diameter of Hexagonal headed screw

As per the results obtained in first modifications on modified hexagonal headed screw, the second modification is suggested to increase core diameter only by 0.2 mm i.e. 1.1 mm. The changes in dimensions are shown in table 7. Again the same load of 100N and moment of 50N-mm is applied as boundary condition and screw is fixed at its head. The results obtained are given in table 8.

TABLE 7

DIMENSIONS OF MODIFICATION 2

Sr.No.	Particular	Symbol	Unit	Values
1	Pitch	P	Mm	0.81
2	Mean Diameter	D_{mean}	Mm	1.5
3	Outer Diameter	D_{out}	Mm	1.56
4	Inner Diameter	D_{in}	Mm	1.1
5	Length	L	Mm	10.92

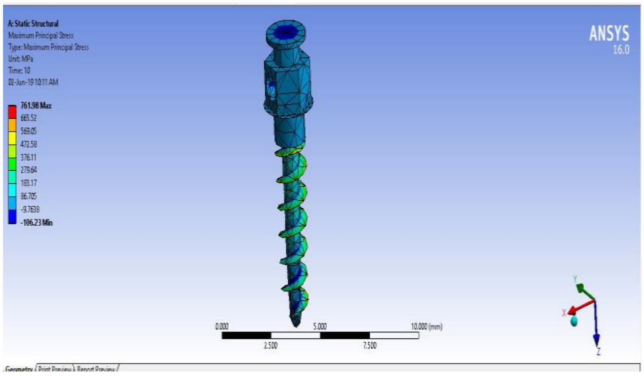

Fig 9. Maximum Principle Stress of Modification 2

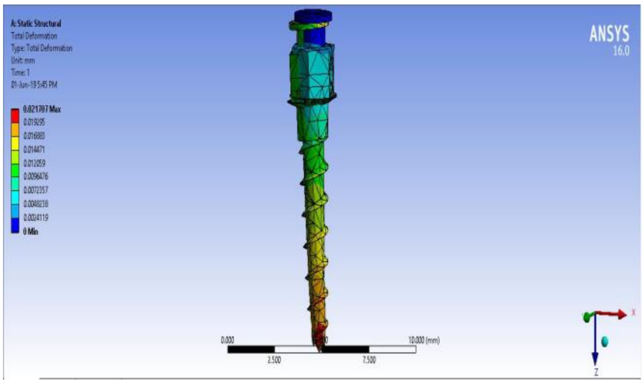

Fig 10. Deformation of Modification 2

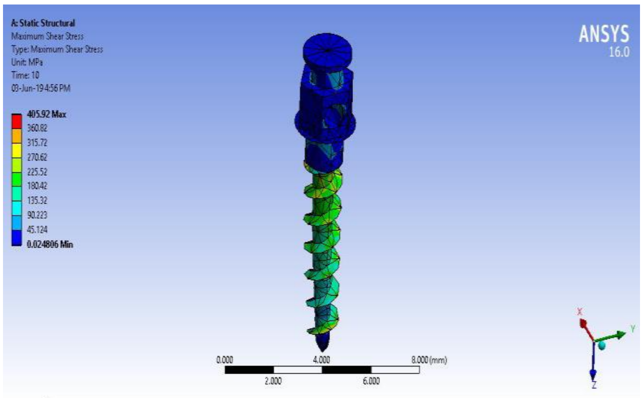

Fig 11. Maximum Shear Stress of Modification 2

From the analysis it is observed that the stresses are reduced well below the yield and shear strength of material. The maximum principal stress is obtained as 660 MPa and maximum shear stress is 405.92MPa and hence this modification is recommended to reduce failure of hexagonal headed screw which reduces pain of patient.

TABLE 8

ANALYSIS OF MODIFICATION 2

Sr. No	**particular**	**Value**
1	Deformation	0.021707mm
2	Maximum shear stress	405.92MPa
3	Maximum principal stress	761.98MPa

TABLE 9

COMPARISON BETWEEN ALL MODIFICATIONS

Sr. No.	Condition	Deformation	Maximum Shear Stress	Maximum Principle Stress
1	Existing hexagonal headed screw	0.060077mm	545.53MPa	883MPa
2	Increase in Pitch and Diameter of hexagonal headed screw	0.0210707mm	309.98MPa	800.36MPa
3	Increase Core Diameter Of hexagonal headed screw	0.021707mm	405.92MPa	761.98MPa

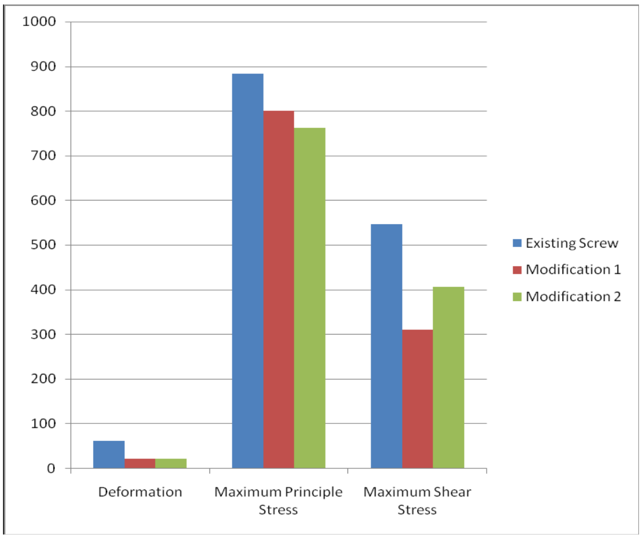

Fig 12. Comparison of deformation, maximum principal stress and maximum shear stress for both modifications suggested

IV. CONCLUSION

Based on analysis over the hexagonal headed screw for dental implant it is concluded that-

1. The stress induced in hexagonal headed screw for its existing design are 883MPa of maximum principal stress and 545.53MPa of maximum shear stress which are greater than the yield and shear strength of screw material and hence failed during operation.
2. Due to failure of screw inside the jaws the screw was removed by operation which is more injurious to the patient.
3. Hence an analysis has been carried out by modifying the screw to reduce its during operation.
4. First modification is to increase pitch and core diameter of screw which reveals that the stresses are reduce to some extent but nearer to yield and shear strength and hence not recommended.
5. Second modification is to increase only core diameter of screw by 0.2 mm which reveals that the maximum shear stress and maximum principal stress are well below yield and shear strength such as 761.98MPa and 405.92Mpa respectively. And hence this modification is suggested to reduce failures in screw.

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