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Review Article

Ti-6AL-4V as Dental Implant

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Abstract: In general, the consideration of titanium alloys plays a crucial role in bio-medical applications. From past decades, use of Ti-6Al-4V in bio-medical applications focused on dentistry, orthopaedic and cardiac implant applications. This research paper targets the bio-compatibility nature of titanium and its alloys. But, the permanent implant applications of titanium alloy results in toxic effects with the use of aluminium and vanadium. To free from these toxic effects, the free alloys of aluminium and vanadium is incorporated in implant applications.

Keywords: Ti-6Al-4V, Implants, Functional Ankylosis, Osseointegration, Zygomatic, Biomedical Applications, Biocompatibility.

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INTRODUCTION

The metallic bio-materials such as stainless steels, cobalt alloy, titanium and its alloys used for the bio-medical applications for their exhibit nature of specific properties which covers a wide path in bio-medical sectors. From literature, many researchers initiated the stainless steels is the first bio-material of metallic category successfully used in implant applications. Later cobalt alloys were used in medical field. After a long research, titanium is introduced as a metallic bio-material in medical applications, mostly focusing in dental field. Titanium and its alloys tasted a peak success as bio-medical devices. These titanium alloys used as implant devices by replacing failed hard tissues in medicine such as bone plates, cardiac valves, artificial hip and knee joints and, artificial hearts. As Ti-6Al-4V has a great influence in medical implant applications with a possibility of toxic effects which results in release of aluminium and vanadium. To make it free, the free alloys of these aluminium and vanadium are introduced for implant applications based on the implants of Ti-6AL-4V that includes Ti-6Al-7Nb, Ti-13Nb-13Zr and Ti-12Mo-6Zr. From last four decades, the maximum number of research activities at various laboratories and organizations had taken place and found the pure bio-compatibility nature of titanium associating with oxides. The Functional Ankylosis as a contact of direct bone implantation with functional basis under load providing different shapes like cones, screws and cylinders e.t.c., and the most suggested shape by this scientist is screw shape that is made up of commercially pure titanium or Ti-6Al-4V with dia of ranging 3.30 to 6.0 mm having length of 6.0 to 16.0 mm (Brånemark, P. I. *et al.*, 1983). The animal model studies by differentiating between Ti oxides and Ti metallic bio-materials with a thin interface layer called ‘Proteoglycans’, that generally appears in between Ti implants and the bones. Only because of surface properties of Ti and its alloys, it is the best metallic material which has bio0compatibility results in inert and stable oxide layers. Due to oxide isoelectric point, high corrosion resistance, low tendency of ion formation in aqueous environments, Electronic Conductivity at low level are the major physical properties of bio-compatible Ti-6Al-4V (Johansson C.B. 1991). The research on various titanium alloys for bio-medical applications and finally stated out of all titanium alloys, Ti-6Al-4V is promisingly most widely used as a bio-compatible material for medical implants only because of its excellent chemical and corrosion resistant nature having a depth of 10 nm on its surface as a chemical stability (Tengvall, P., & Lundström, I.

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1992). The focused on the research activities on commercially pure titanium and its alloy implants in the bones of the rabbits by briefing that when implant is twisted, the Ti-6Al-4V implants performs lower removal torque when compared with commercially pure Ti and occurring a significance of bone contacts in rabbits (Johansson, C. B. *et al.,* 1998). The study of the microstructure using plastic deformations of the billets that was considered worked in all ways for increase of properties of Ti alloys mechanically. For increasing the mechanical properties of commercially pure titanium, new process and techniques came into existence for avoiding the release of ions that can provide best fatigue, good strength and also improves the ductile nature of Ti (Valiev, R. Z. *et al.,* 2000). The research work came to know that ultimate tensile strength of commercially pure titanium retains the ductility with a percentage of 11 and showed the possible utility of Ti in dental applications. This was done on bone tissues of the rabbits and evaluated the results of torque removal experiments and for validating it, required parameters were calculated (Parel, S. M. *et al.,* 2001). The research helped in treating the patients suffering with tumour resection having maxillary structure loss. Many of the victims retain anchorage in orthodontics in the zygoma body regions or frontal area of zygomatic bones. His research helped in extension of using longer implants by penetrating the maxilla region to alveolar crest as a possible case treatment (Duarte, L. R. 2007). The use of silver nanoparticles in dental practice plays a dominant role in root canal treatments and respective synthesis and characterization takes place for better application in the context of endodontics (Bammidi, R. *et al.,* 2019).

TI-6AL-4V AS A DENTISTRY DEVICE

The titanium alloy, 'Ti-6Al-4V' is generally used in dental applications in the form of dentistry devices such as bridges, crowns, dental implants, abutments and also screws. The pure form of this alloy is used for endosseous dental implant applications. Basing on ASTM grades of titanium, the titanium grade 5 which we call Ti-6Al-4V and it consists of 6% aluminium and 4% vanadium had the strongest nature. The grade 5 of titanium had the mechanical properties for implantations basing on ASTM are framed in the following tabular form.

Table-1. Grade 5 Mechanical Properties.

Mechanical Properties	Values
Yield Strength	795 Mpa
Ultimate Tensile Strength	860 Mpa
Elastic Modulus	117 GPa
Elongation	10%

This grade 5 titanium is generally used as an alloy in annealed state more in medical implants than in dental applications. It performs low wear resistance and shear strength if we used in any Orthopaedic cases. The mechanical properties like young's modulus are not supportable for this particular case due to its difference in values. To overcome this kind of problems, the titanium alloys like Ti-6Al-4V came into existence and was introduced for bio-medical applications. Basing on commercially pure titanium or Ti-6Al-4V mechanical properties, the dental implants are classified into following categories such as Functional Ankylosis, Anchorage in Orthodontics and Zygomatic.

FUNCTIONAL ANKYLOSIS

This type of implantation is technically named as Osseointegrated Implant. This implant gives the information regarding direct bone to implant contact and its functional foundation under loads. This dental implants designed variety of shapes that has been commercially made up of pure titanium or Ti-6Al-4V which includes cylindrical shapes, cone shapes, hollow shapes and screws shapes having length and diameter ranging from 6.0 to 16.0 and 3.30 to 6.0 mm. This implant of Ti-6Al-4V has the best material properties performing the better functionality with the bone contact of which the important component is dental implant.

Figure-1. Functional Ankylosis.

The implants are of different shapes having the same parts having direcgt bone contact. The surface modifications of implant takes place for biological response of Ti-6Al-4V shows the tissue reactions because of its physical, chemical and mechanical properties of Ti-6Al-4V. the abutment is one of the component which mantains a contact with tissue by connecting to the implant with a screw. And the other is crown attached to abutment with screw made up of Ti or Au alloy or cement having diameters and lengths of ranging from 3.30 to 6.0 mm and 6.0 to 16.0 mm. The internal fractures takes place due to fixation. So, the implant must be manufactured with Ti-6Al-4V to avoid respective fractures during the implantation. During the fracture healing process the ions of aluminium and vanadium are released. After certain weeks, the effects of toxins due to release of aluminium and vanadium ions takes place. For avoiding this particular issue, the development of Ti-6Al-4V processing for the maximum increase in the mechanical properties must happen. The processing includes the improvement of fatigue resistance and the best strength and toughness will be provided. The commercially pure titanium significantly gives high torque than alloy implants which is one of the bio-mechanical parameter. This torque is generally varies in between 17.0 to 19.0 N-cm as per ASTM Grades.

Figure-2. Osseointegration.

ANCHORAGE IN ORTHODONTICS

It is general way of tooth movement that was resisted by using different techniques. In general, the factors affecting orthodontic anchorage are root number, multi-rooted, size, length and root shape. The values of these factors are dependent of root surface area. The orthodontic implants secure the anchorage in various treatments. This type of implants may have a chance of deformation due to orthodontic loads and the dia of these implants generally varies in between 1.20 to 2.0 mm. The strength of Ti-6Al-4V is more than the commercially pure titanium due to its alloy nature. Here, the implants are usually made up of Ti-6Al-4V.

Figure-3. Anchorage Dental Mini Implant

This type of implant does not achieve the osseointegration. Generally, the corrosion resistance of commercially pure titanium is more than the Ti-6Al-4V which fails in allowing the release of metal ions. But, the unalloyed titanium doesn't prefer for implantation. So to implant, the Ti-6Al-4V is considered. The trails had been carried out between two rabbit's teeth for which the load was applied to one and other assigned to zero load.

Figure-4. Orthodontic Anchorage.

The plastic deformations and shear strength of implant in case of Ti-6Al-4V and commercially pure titanium was calculated basing on the stress analysis after the load and no load allocated to the considered rabbit tooth. From the investigations, it is clear that the concentration which was detected in case of vanadium failed in abilities of toxins in rabbit models. The anchorage in orthodontics improves the behaviour of mechanical properties of Ti-6Al-4V.

ZYGOMATIC DENTAL IMPLANTS

These types of implants are usually made up of commercially pure titanium. There are various techniques in dealing this type of implant concentrating different clinical considerations for evaluating the final outputs. In this type of dental implant have a length of range from 29 to 55 mm and 4.5 mm diameter. This implant penetrates into premolar region having longer in length if we compared to regular dental implants. From the literature, it is very clear that a large number of patients are suffering with retaining problems in the regions of anchorage in orthodontics. It will be preventive if the modification takes place in the dental implants.

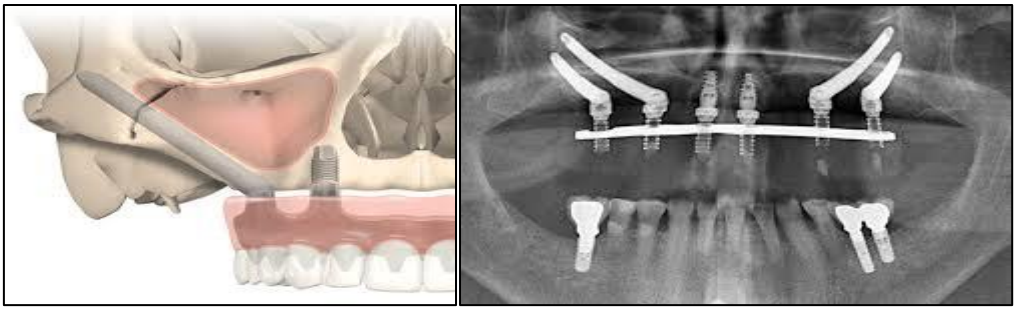

Figure-5. Zygomatic Fixtures.

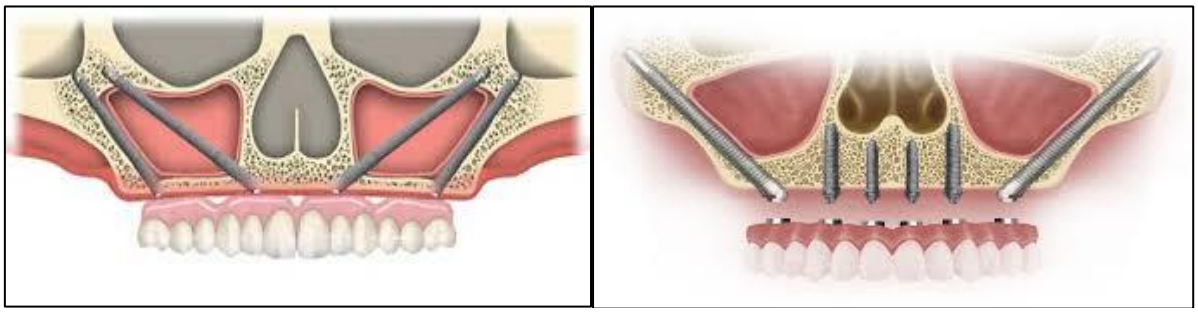

Figure-6. Zygomatic Dental Implant.

This dental implant involves a procedure of well-defined machined surface made of commercially pure titanium screws ranging from 30.0 to 52.5 mm in 7 different lengths with dia 4.0 to 5.0 mm. Generally, the zygomatic implants were placed in premolar regions of oral division. The configurations and sizes of these implants help in opting the best techniques and procedures for implantation. This phenomenon describes the best alternative treatments for the concepts of loading. Many researchers focused on this technique of implantation and finally proved that conventional method gives the best output in zygomatic case. The huge number of research articles showed the clinical applications of zygomatic fixtures and respective extension procedures in premolar regions dealing with ultimate manufactured drills visualized during oral implant surgeries.

RESULTS AND DISCUSSIONS

The commercially pure titanium and Ti-6Al-4V created a key path in biomedical applications. Ti-6Al-4V has excellent bio-compatibility nature

demanding peak level of reliable performance in biomedical field. The category of dental implants requires different mechanical properties for which the material is of Ti-6Al-4V or of commercially pure titanium. The Functional Ankylosis Dental Implant defined the nature of loading as direct bone-implant contact for which these implants are of different shapes such as screws. These screws are of commercially pure titanium or of Ti-6Al-4V with respective geometrical dimensions. This implant parts are explained and surface modifications takes place and analysed the alloy ion release. The different processes and manufacturing methods are considered for better mechanical properties basing on ductility, strength and corrosion.

Orthodontics in Anchorage Dental Implant was studied in case of load application for which the deformation in mini implant had taken place and these orthodontic implants are usually made with commercially pure titanium or of its alloy called Ti-6Al-4V. It also deals with the corrosion resistance of which values are comparatively low in Ti-6Al-4V than commercially pure titanium. The removal torque is also considered here and stress analysis is evaluated. All these cases are trailed on rabbit models. One model is loaded and other was unloaded in rabbits, the stress analysis with removal rate torque is considered and evaluated for the output of stability which results in increase of biocompatibility nature in Ti-6Al-4V when compared to commercially pure titanium.

These dental implants are of commercially pure titanium which generally takes place at premolar regions of frontal extension of zygomatic bone. The researchers suggested the conventional technique for best outputs. These also used like posterior anchorages treating the traumas victims with the involvement of clinical considerations and procedures. This is one of the excellent conventional methods in dental implantation.

CONCLUSION

This research article concludes that the use of biomaterials in dental applications. Ti-6Al-4V or commercially pure titanium explained its biocompatibility in the application of dental implants. Ti-6Al-4V has excellent nature of biocompatibility and performs best mechanical properties. The rabbit models are considered and dental implants are implanted to these models for which it can replace the failed hard tissues by the Ti-6Al-4V. The titanium alloys, particularly Ti-6Al-4V had an outstanding corrosion resistance which is a key factor for biomedical applications.

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