Original Article

Evaluation of surface changes of stainless steel miniplates and screws following retrieval from maxillofacial trauma and orthognathic surgery patients: A comparative study

ABSTRACT

Background: Metal implants have the potential to degrade body fluids. Corrosive degradation has been demonstrated in laboratory tests, both under simulated clinical conditions and by electrochemical methods, as well as in studies of retrieved metal implants. The clinical importance of degradation of metal implants is evidenced by particulate corrosion and wear products in tissue surrounding the implant, which may ultimately lead to bone loss.

Materials and Methods: The present study is to evaluate the surface changes such as corrosion, surface roughness, and microfractures and for the tensile strength of 18 stainless steel miniplates and 18 stainless steel screws which were used as rigid internal fixation in the management of maxillofacial fractures and orthognathic surgeries.

Results: In this study, surface roughness and microfractures were found in all the miniplates and screws that is 100%. Corrosion degradation was found in 12 of 18 plates that is 66.66%.

Conclusion: Our results through scanning electron microscopy and stereo electron microscopy showed surface roughness, microfractures, and corrosion. However, tensile strength was not affected when the plates were *in situ*. Through our study, we recommend their retrieval after the purposes of rigid fixation have been fulfilled.

Keywords: Corrosion, microfractures, stainless steel miniplates and screws, surface roughness, tensile strength

INTRODUCTION

Miniplates have been used during the last decades to facilitate stability between bony fragments in the maxillofacial region and are nowadays the preferred method for fixation of fractures and osteotomies. The healing was by primary bone healing with osteons laid down in axial direction of the bone. Primarily, stainless steel miniplates and screws (Fe-Cr-Ni-Mo alloys) are commonly used. Metal implants have the potential to degrade body fluids. Corrosive degradation has been demonstrated in laboratory tests, corrosion, and wear products either as metal ions or particles may give rise to biological changes in the tissues adjacent to implants, ranging from mild fibrosis to infection and necrosis.[1-3]

The clinical importance of degradation of metal implants is evidenced by particulate corrosion and wear products in

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Mouneshkumar Chapi Devendrappa, Madhura Dattatraya Kulkarni[1], Nazia Haidry[2], Pranay Kulkarni[3], Flora Verma[4], Dhanashree Anand Pawar[5]

Department of Oral and Maxillofacial Surgery, School of Dental Sciences, Krishna Institute of Medical Sciences, Deemed University, [5]Intern, School of Dental Sciences, Krishna Institute of Medical Sciences, Deemed University, Karad, [1]Department of Oral and Maxillofacial Surgery, Bharati Vidyapeeth Dental College and Hospital, Sangli, Maharashtra, [2]Private Dental Practitioner, [3]Dental Surgeon, Government of Bihar, Patna, Bihar, [4]Oral and Maxillofacial Pathology, Senior Research Fellow, CDER, AIIMS, New Delhi, India

Address for correspondence: Dr. Mouneshkumar Chapi Devendrappa,
Department of Oral and Maxillofacial Surgery, School of Dental Sciences, Krishna Institute of Medical Sciences, Deemed University, Karad, Maharashtra, India.
E-mail: mouneshk337@gmail.com

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tissue surrounding the implant, which may ultimately lead to bone loss. Thus, this study is to evaluate the surface changes for corrosion, surface roughness, microfractures, and tensile strength of 18 stainless steel miniplates and 18 stainless steel screws.

MATERIALS AND METHODS

The study was carried out during the period of September 2006–September 2008 at the Department of Oral and Maxillofacial Surgery of our institute. The surface changes such as corrosion, surface roughness, microfractures, and tensile strength of 18 stainless steel miniplates and 18 stainless steel screws were evaluated, which had been used as rigid internal fixation in the management of maxillofacial fractures and orthognathic surgeries. After explaining the study protocol, written consent was obtained from patients. Symptomatic patients with complaints of the presence of infection, intraoral sinus or extraoral sinus opening, and dehiscence at the operated site were included, and medically compromised patients were excluded.

The retrieved stainless plates and screws were examined with the aid of scanning electron microscope (SEM-JSM 840) in the Department of Metallurgy, Indian Institute of Science, Bangalore. Before examining the sections under the SEM, the specimens were coated with a thin (about 2 nm) gold layer by a sputtering process (EMITECH, K550) for achieving a better topographic contrast. The retrieved stainless plates and screws were microscopically examined with the aid of stereo electron microscope.

The retrieved stainless plates and screws were then subjected to universal testing machine (UNITEK 9450) for measuring the tensile strength. The plates were held in a holding device and mounted onto the jaws of the testing machine. The plates were tested at a constant crosshead speed of 2 mm/min. The peak load at which the plates failed in tension was noted down as ultimate stress.

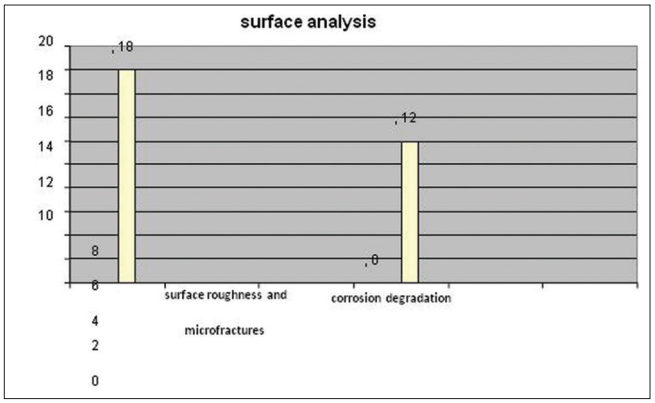
RESULTS

Surface roughness on the surface of a majority of the plates could be observed usually as sharp-edged scratches on the free surfaces as well as on the countersink areas of the plates. Microfractures were seen in the countersink regions, sometimes leaving metal tongue formation or splinters. The surface roughness and microfractures were due to handling and bending of plates during placement and also during drilling injuries in the countersink areas. Corrosion degradation was seen in the countersink areas, often with break in the continuity of the metallic surface appearing as patches often localized to the countersink areas involving one or two countersinks within the same plate. Corrosion never extended onto the free surface outside the countersink area. Bone tissue covering parts of the countersink region was seen associated with a screw hole in two of the stainless steel plates. Graph I represents the surface analysis of maxillofacial plates and screw. Graph 2 represents the reason for maxillofacial plate removal. Graph 3 represents the site of plate removal. Graph 4 represents the tensile strength of plates.

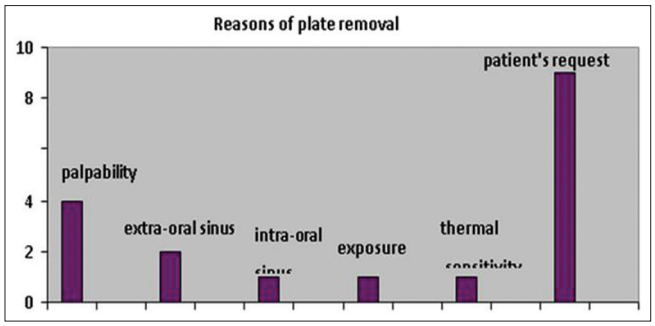
DISCUSSION

Metal implants become a useless foreign body and a potential source of problems once their purpose is served. For this reason, miniplate retrieval should be advised on routine basis after bone healing has occurred as it is better and easier to retrieve asymptomatic implants than symptomatic implants. Implant failure is multifactorial which mainly depends on the quality control by the manufacturer and use of the proper technique by the surgeon. Stainless steel miniplates and screws are used for rigid internal fixation to immobilize fractures of the maxillofacial skeleton and osteotomies in orthognathic surgeries. But should nonfunctional miniplates and screws be removed after a few years.[4-11]

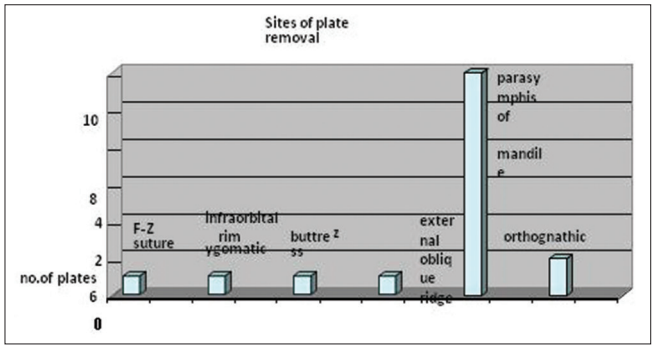
Removal of miniplates has remained controversial. According to researchers, who oppose the removal of an asymptomatic miniplate, biocompatibility of material, low incidence of complications, the risks of general anesthesia during removal, possible damage to adjacent anatomical structures, and the expense of removal contraindicate removal of asymptomatic miniplate. On the contrary, authors who favor removal argue that the miniplate can possibly act as a foreign object with the potential to cause complications, and also, miniplates generate growth restrictions among patients.[12]



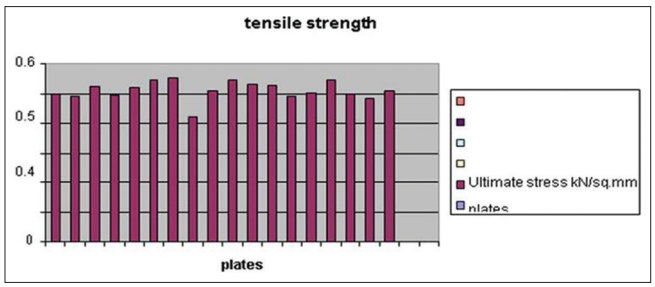
Graph 1: The number of maxillofacial plates and screws showing surface roughness, microfractures, and corrosion degradation



Graph 2: Reasons of plate removal



Graph 3: Sites of plate removal



Graph 4: Tensile strength

Brian Alpert *et al*. provided a variety of reasons to support the concept of plate removal. The reasons being metal toxicity, allergy, stress shielding, metallosis, oncogenicity, migration, radiation/X-ray effect, palpability, reinjury, thermal sensitivity, loose hardware, perforations, exposure, and infection.[13,14]

Matthew *et al*. through their pilot study cited indications for miniplate removal as wound infection, wound dehiscence, exposed implant, thermal conductivity, before insertion of prosthesis, patient concern, tenderness, palpation, and persistence paresthesia. Mofid *et al*. who studied the biocompatibility of the fixation materials in the brain indicated that there is a progressive increase in inflammatory response surrounding stainless steel miniplates.[15-17]

A histological analysis of the effects of the stainless steel miniplates by Nazzal *et al*. indicated that there is an increase in the inflammatory cells with increase in the time of implantation of miniplates and screws.[18-21]

We evaluated the surface changes such as surface roughness, microfractures, and corrosion in 18 stainless steel miniplates and 18 stainless steel screws retrieved from patients treated for maxillofacial trauma and orthognathic surgeries. The surface changes were evaluated using SEM and stereo electron microscopy. Further, the same samples were tested for tensile strength using universal testing machine. The rate of removal according to site is as follows: frontozygomatic suture 5.55%, infraorbital rim 5.55%, zygomatic buttress 5.55%, external oblique ridge 5.55%, parasymphysis of mandible 66.66%, and bilateral sagittal split osteotomy 11.11%. The reasons for miniplate removal were as follows: extraoral sinus 11.11%, palpability 22.22%, intraoral sinus 5.55%, plate exposure 5.55%, thermal sensitivity 5.55%, and patient's request 50%.

In our study, 18 stainless steel miniplates and 18 stainless steel screws were evaluated. Surface roughness on the surface of a majority of the plates could be observed usually as sharp-edged scratches on the free surfaces as well as on the countersink areas of the plates. Microfractures were seen in the countersink regions, sometimes leaving metal tongue formation or splinters. The surface roughness and microfractures were due to handling and bending of plates during placement and also during drilling injuries in the countersink areas. Corrosion degradation was seen in the countersink areas, often with break in the continuity of the metallic surface appearing as patches often localized to the countersink areas involving one or two countersinks within the same plate. Corrosion never extended onto the free surface outside the countersink area. Surface roughness and microfractures were found in all the stainless steel miniplates and screws that is 100% and corrosion degradation was found in 12 of 18 stainless steel miniplates that is 66.66%.

In our study the tensile strength of 18 stainless steel miniplates was evaluated. A mean value of 511N was exhibited by the retrieved miniplates which was enough to withstand the masticatory forces. The maximum masticatory forces in healthy young individuals have been measured as 660N in molar region and 290N in incisor region. However, these forces are probably higher than the forces exhibited during postoperative period.

Our results through SEM and stereo electron microscopy showed surface roughness, microfractures, and corrosion. However, tensile strength was not affected when the plates were *in situ*. Following the symptoms of retained stainless steel plates and screws, we recommend their removal after the purposes of rigid fixation have been fulfilled.

CONCLUSION

Metal implants become a useless foreign body and a potential source of problems once their purpose is served. For this reason, miniplate retrieval should be advised on a routine basis after bone healing has occurred as it is better and easier to retrieve asymptomatic implants than symptomatic implants. Release of metal particles into tissues from miniplates and screws is undesirable and may be minimized by careful surgical technique. In addition, metal implants should be free from rough edges or protuberances on the surfaces to minimize the risk of detachment and deposition of particles into surrounding tissues.

In our study, surface roughness and microfractures were found in all the stainless steel miniplates and screws that is 100%. Corrosion degradation was found in 12 of 18 plates that is 66.66%. In our study of tensile strength of 18 stainless steel miniplates, a mean value of 511N was exhibited by the retrieved miniplates which was enough to withstand the masticatory forces. With this study, we recommend the retrieval of stainless miniplates and screws after their purpose of rigid fixation is served. However, long-term studies need to be carried out for further supporting the results.

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Conflicts of interest

There are no conflicts of interest.

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