A scanning electron microscopic study on the HA-coating of implant following insertion into the cadaver goat jaw bone

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Abstract

The dental implant is being widely used for the purpose of both function and aesthetic rehabilitations. Endosseous dental implants are available with various surface characteristics ranging from relatively smooth machined surfaces to more roughened surfaces by coating, sand blasting, and acid treatments or by a combination of the treatments. The ultimate goal of modern implantology is to achieve proper osseointegration, which is largely dependent on the macro- as well as micro- design of the implant. HA-coating of implant surface is a predictable means for producing the micro-design. It has got the ability to act as osteoconductive matrix on which the growth of new bone can take place thus enhances osseointegration when implanted in osseous sites. Alteration of the surface coating due to torque force during insertion into osteotomised bone can hamper osseointegration. Therefore, an experiment has been carried out to determine the surface changes of dental implants occurring during insertion into cadaver goat jaw and observed under scanning electron microscope.

Keywords: Dental Implant, Surface Coating, Osseointegration, Scanning Electron Microscope.

Introduction

Endosseous dental implants are available with various surface characteristics ranging from relatively smooth machined surfaces to more roughened surfaces by coating, blasting by various methods, by acid treatments or by a combination of the treatments.(1) Textured surface also allows ingrowth of the tissues.(2,3) Some of these have the ability to enhance and direct the growth of bone and achieve osseointegration when implanted in osseous sites.(4) Altering the surface topography of an implant by roughening can greatly improve its stability.(4) Based on the scale of the features, the surface roughness of implants can be divided into macro, micro and nano-sized topologies.(5,6) Surface irregularities of an implant can be designed by making porous and/or by coating the implant surface with other suitable materials to increase bone implant contact(7,8). A bio inert surface is one which itself does not play a role in osseointegration. It merely forms a favourable substrate for the osseous deposition to occur, whereas a bioactive surface is one which actively participates in the osseointegrative process due to the reaction between the chemically modified surface coating and the surrounding bone. Successful osseointegration is usually associated with osteogenesis, osteoconduction and osseoinduction. Osteogenesis is the formation and development of bone. Osteogenic cells encourage bone formation in the soft tissues or activate more rapid growth in osseous sites. Osteoconductive surfaces are conducive to bone growth and allow bone apposition onto it from existing bone, but they do not produce bone formation. To encourage bone growth across its surface an osteoconductive surface is preferable. Substances, such as Calcium Phosphate and Ca-hydroxyapatite (HA) coatings can be given to implant surface to make it osteoconductive. But the coating may suffer some kind of damage during the process of implantation due to insertion torque. The objective of present study is to observe the changes of HA-coating of implant surface under Scanning Electron microscopy following insertion into goat bone.

Materials and Methods

The present study was carried with fresh goat mandibles, obtained from various slaughterhouses within 1 hour of sacrifice of goat which still supposedly maintained the vitality of bone. The natural ridge in the retromolar area was selected in the freshly procured goat mandible (Fig. 1)(10). Two dental implants were obtained from CORTEX Company with various specifications as depicted below:

1. Material: Ti6Al4V
2. Shape: Conical angle
3. Threads: Square profile
4. Design type: Internal Hexagon

Coating of dental implant: Implants were coated with synthetic hydroxyapatite by plasma spraying method (Fig. 4) at Central Glass and Ceramic Research Institute (CGCRI), Kolkata.

The implantation procedure: The jaw was held with the help of a vice and the implants were inserted into the goat jaw bones using the standard protocol (Fig. 1 & Fig. 2). Then, the implants were removed from the osteomised site (Fig. 3) and were subjected to SEM study (Phenom ProX desktop scanning electron microscope). The SEM observations were made and the changes were observed on the monitor. Inbuilt camera was used for the photography of the selected field at various magnifications such as x150, x600, and x3600 (Fig. 4 to Fig. 7).

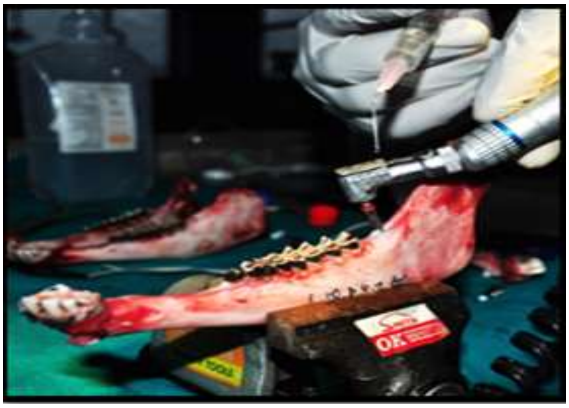

Fig. 1: Osteotomy site prepared into jaw bone

Fig. 2: Dental implant inserted into the osteotomy site

Fig. 3: Dental implant recovered from the osteotomy site

Fig. 4: SEM microphotograph of coated dental implant at x150

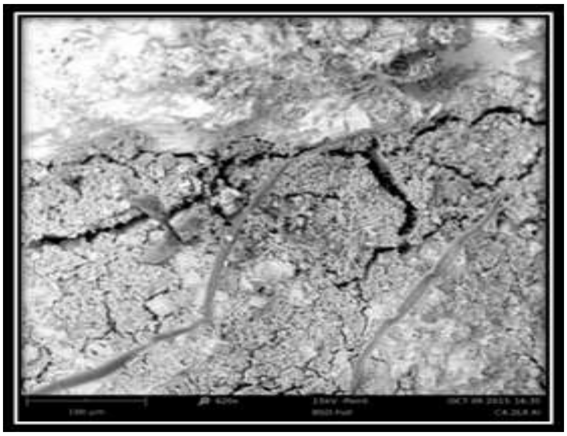

Fig. 5a: The SEM microphotograph of coated dental implant before insertion (x600)

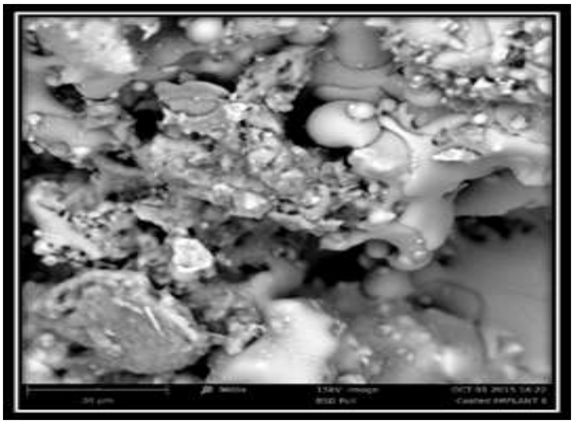

Fig. 5b: The SEM microphotograph of coated dental implant before insertion at higher magnification(x3600)

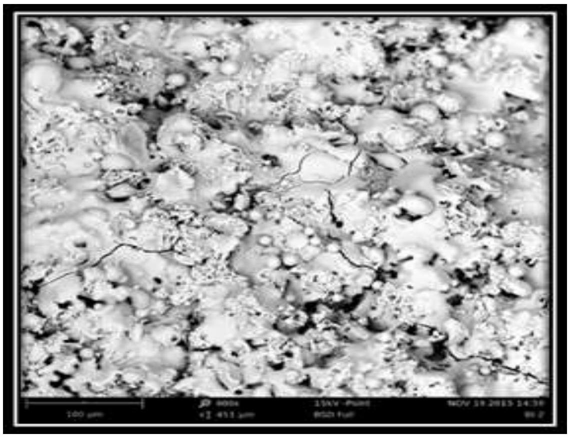

Fig. 6a: The SEM microphotograph of coated dental implant of Ø3.8mm after insertion (x600)

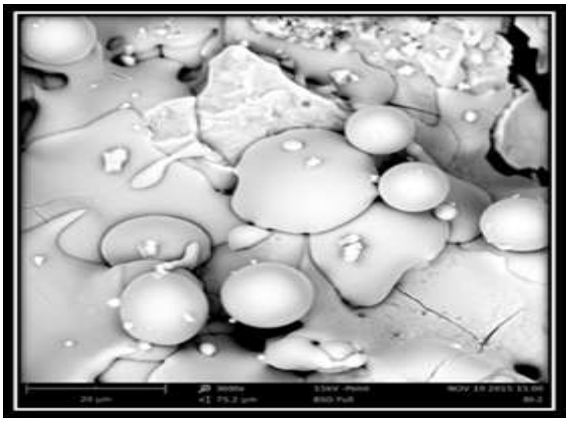

Fig. 6b: The SEM microphotograph of coated dental implant of Ø3.8mm after insertion at higher magnification (x3600)

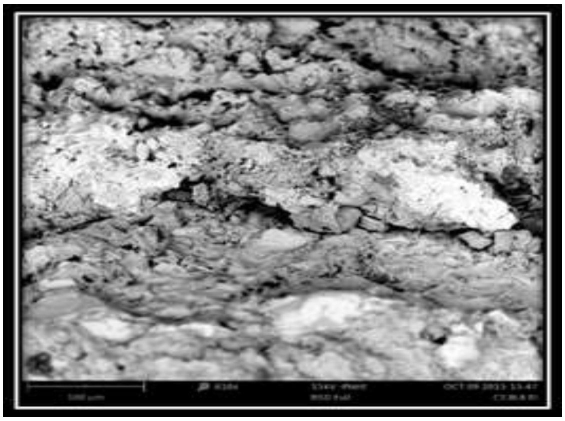

Fig. 7a: The SEM photomicrograph of coated dental implant of 4.2mm Ø after insertion (x600)

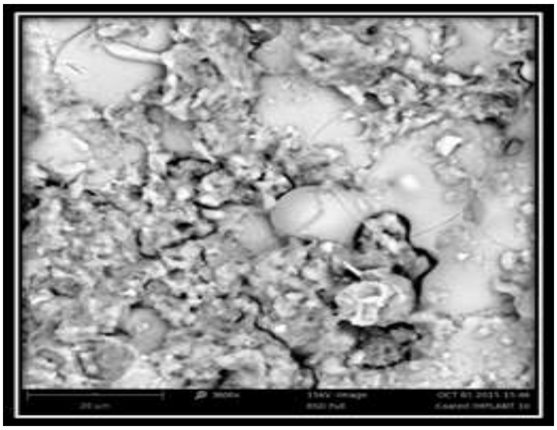

Fig. 7b: The SEM photomicrograph of coated dental implant of 4.2 mm Ø after insertion at higher magnification (x3600)

Results and Discussion

The scanning electron microscopic observation of the unused HA-coated unused implant shows an uneven surface layer of calcium hydroxyapatite with dome shaped elevations and adjacent concavities representing porosities (Fig. 4, 5a, 5b). The inserted implants were harvested by unscrewing. The coated implants surface had suffered an insertion torque force. This was reflected on the surface layer in the form of cracks and loss of HA coating in a sprawling manner. The implant with higher diameter (L10 X D4.2) had suffered significant loss of surface layer in the form of discrete cracks on the coated surfaces at random. It also had lot of soft tissue debris probably entangled over the surface during implant removal. However, the inserted implants should have been removed by fracturing the bone instead of unscrewing. Although the surface damage was also observed on 3.8mm diameter implant but the cracks were inconspious compared to 4.2mm diameter implant. The breakage of dome shaped areas were observed on the surface of 3.8mm diameter implant was less compared to 4.2mm of implant. It is postulated that higher diameter implant was required to be inserted with much torque force than with the lesser diameter implant. This can also be interpreted that the higher diameter implant had more implant- bone contact compared to the lesser one. The reasoning for such difference in damage and its pattern on the dental implant surface may vary upon the type of coating and its thickness; and also on the material with which was coated. This has been observed that the types of surrounding hard tissues in the cadaveric goat jaw bone and its characteristic property can alter the surface of coated dental implant. The macro design of dental implant here is described in terms of length and diameter that have been conclusively observed under SEM photomicrograph. The coating used was calcium hydroxyapatite, here denoted as HA coated surface, and was meant for better connections with the surrounding bones. The scanning electron microscopic observation are very clear and conclusively have shown that with increase in diameter and length of the implant more amount of damage are observed on the surface coatings. Therefore, the scanning electron microscope evaluation can help us to observe changes over the surface coating of dental implants at different qualities of alveolar bone.

Future scope

Bioactive coating implant surface improves upon bonding between implant and bone. Bioactive materials such as hydroxyl apatite (HA), bioactive glass may well be used as coating material on implant. Removal of such coating from the implant surface may perhaps takes place due to increase in thickness of coating ,lack of proper bonding of material to implant surface, improper chemical composition of coating material. Improvement on these aspects may perhaps be novel perspective for future research

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