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Evaluation of bone quality in dental socket with two different approaches for ridge preservation using grey scale imaging and Novel Micro CT

Alveolar socket bone loss has been one of the major problems after a tooth extraction. Various techniques are used currently to augment the bone for preparing the site for implants which include grafting, distraction osteogenesis etc. Despite of various treatment options each of them has limitations.

After tooth extraction, the extraction socket heals by forming a blood clot which leads to the formation of new bone within 3-4 months. Although bone deposition in the socket will continue for several months, it will not reach the crestal level of the neighbouring teeth. The resulting alveolar bone loss may lead to problems such as poor aesthetic appearance and difficulty in placement of implants or prostheses for partially or totally toothless patients. Various techniques have been proposed to limit alveolar bone loss such as atraumatic extraction, immediate post-extraction removable prosthesis, immediate placement of dental implant and immediate bone-filling of extraction socket. Guided bone regeneration (GBR) and guided tissue regeneration (GTR) has been gaining attention in recent years for repair of bone defects and had been used in patients after tooth extraction with the aim of preserving alveolar bone. Most works are focused on assessing the height or width preservation in a healing socket.

The current study is focused on comparing the healing and bone quality after using two different approaches to ridge preservation in the mandibular arch. Bioscaff Alvelac, a resorbable PLGA scaffold was evaluated clinically in comparison to Xenograft on 9 subjects and an Orthopantomogram radiograph was taken immediately after the placement of scaffold and after three months. The digital image processing of the OPG was done to evaluate the bone density distribution in the extraction socket after three months with the Bioscaff Alvelac and Xenograft respectively. The results indicate better bone density in sockets with the scaffold compared to those sockets which were grafted using a Xenograft. In order to confirm the observation, the bone microarchitecture was evaluated using a micro CT for an example case.

Materials and methods

On the basis of these considerations a clinical case study comparing the performance of a Xenograft and Bioscaffold in an extraction socket was considered at the Rajan Dental Institute Chennai India. The performance was evaluated based on bone quality and ridge preservation characteristics. In order to compare the healing, patients who have requirement of removing two teeth in the same ridge (mandible/maxilla) were selected and in one socket PLGA scaffold was used while the other socket was packed with a Xenograft widely used for grafting applications which is used as an alternative in socket preservation. The Xenograft was filled on the second socket and was closed with a collagen membrane. The OPG radiograph was taken immediately after extraction of the teeth with the scaffold and the Xenograft placed in the other socket The scaffold being radio lucent while the graft material being radio opaque it was possible to monitor both the healing as well as changes in radiolucency with healing on the socket treated with PLGA scaffold. The socket radio opaqueness changes with new bone formation and also the bone density at the location. The changes in socket radio opaqueness was also monitored with healing in case of socket treated with the Xenograft. This was accomplished by comparing the

gray value distribution in the socket area whose contour was carefully drawn on the digital OPG. This way a clear comparison of healing pattern could be observed on both the sockets. The scaffolds were placed in post extraction sockets across the buccolingual width with the length of cylinder spans across the width in the coronal third of the socket. Follow up OPG was taken after 12 weeks and the histogram profile along the socket contour area were taken to check the changes in absorbance of X-ray. In addition to the above, a micro CT was done on the bone sample trephined from the healed socket after the treatment at the time of placement of implant to compare the efficiency of the both the techniques.

Case study 1

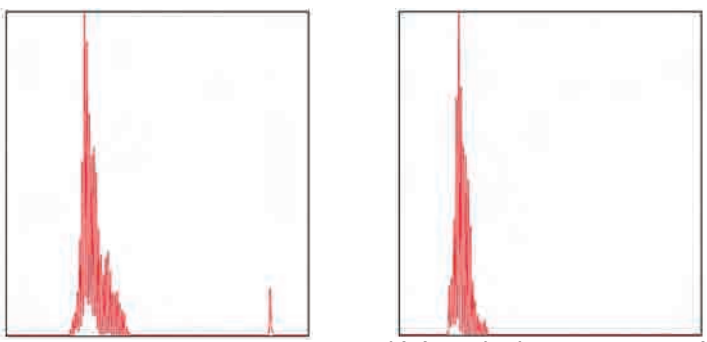
In the current study, a 24 year old female patient had extraction of two incisors in the lower jaw and the adjacent sockets after extraction were treated with two different methods. One of the socket was grafted with commercially available Xenograft and covered with a membrane while Bioscaff Alvelac (a synthetic scaffold made of polylactic-co-glycolic acid) was placed and was closed with a simple interrupted suture.

The OPG of the patient was taken immediately after the procedure and was subsequently followed up after 3 months. Figure 1, shows the OPG taken on the patient immediately after placement of scaffold/grafting the socket.

The contour of the post extraction socket was carefully drawn and the gray values within the area of the contour were plotted as bar chart (no of pixels having same gray value). The histogram profile was done on socket 31 (grafted with Xenograft)and socket 41 (treated with PLGA scaffold). The standard deviation of the distribution of no of pixels having similar gray values in the socket 31 (grafted with Xenograft) was 24.66 indicating that was a higher variation gray values of pixels in the given socket contour area. While the socket treated with a scaffold at the crestal level had a standard deviation of 6.85 meaning the variations in gray values of pixels within the socket area were minimum. Moreover the Mean gray values of socket 31 and socket 41 were 77 and 53 respectively. It is known that higher the gray value of a pixel, higher is the absorbance of X-rays for the given pixel (as X rays get absorbed more, the pixel has higher gray scale value in 0-255 scale where 0 is for Black while 255 is assigned to white) meaning increased radio-opaqueness due to bone or bone like substances. After a tooth extraction it is known that the socket is filled with blood and the radio-opaqueness is low while for socket packed with Xenograft the radio opaqueness is likely to be higher due to Xenograft granules. This is clearly seen in socket 31 compared to socket 41. The socket 41 has lower gray level in the socket contour area as it mainly has the blood clot and the scaffold both of which have low radio opaqueness. However, socket 31 is grafted with granules of the graft material; the intergrannular space has lower radio opaqueness which causes high degree of variation in gray levels. This results high standard deviation values of gray level distribution in socket 31.

Figure 1: OPG of the patient immediately after extraction and treatment of socket with Xenograft and Bioscaffold

Figure 2: Histogram of the gray level distribution in a (a) socket 31 and 41 immediately after extraction in patient 1.



a) (Standard Deviation= 24.66) b) (Standard Deviation= 6.85)

The above OPG picture, Figure 3, shows a typical healing of the anterior sockets 31 and 41 with Xenograft and Bioscaffold respectively. The histogram of gray level distribution, Figure 4 a & b, in the contour area of the sockets 31 and 41 is different from the one which was done immediately post extraction. It can be clearly seen the Standard Deviation of gray level distribution had dropped considerably to about 50% of the original values in the socket contour area in both the sockets. Though the skewness and kurtosis of the distribution showed some differences, it is very difficult to conclude on the bone quality except that socket grafted with Xenograft still shows high degree of

variation compared to the one with Bioscaffold. Clear indication of healing could not be obtained from the OPG. In order to get a better picture of healing, a bone sample was extracted from both the sockets and was examined using a novel micro CT Technique which gives a 3 dimensional picture of the bone.

For ultrastructural evaluation of Osteocytes lacunae and its canal network using the novel MicroCT (Xradia Inc, Pleasanton, USA), a piece of cortical bone about 500 microns in diameter was prepared. The sample was scanned with the MicroCT and the results are shown below.

It can be clearly seen from Figure 5, that the Micro CT is able to clearly distinguish between the bone extracted from the two different sockets. The socket with the Bioscaffold had natural bone with the osteocytes while the bone sample from the socket which had Xenograft shows lack of osteocytes. In addition, sample grafted with Bioscaffold shows greater presence of soft tissues in Figure 6. The correlation between the conventional histology and novel Micro CT was demonstrated in the earlier paper by the authors on comparison of histology of bone extracted and the corresponding Micro CT. The picture below provides a typical example of correlation between histology and Micro CT.

It can be seen from the above pictures that Micro CT is able to clearly identify the osteocytes and the compact bone and even to the extent of remnants of PLGA scaffold with similar resolution if not better

Figure 3: OPG of the patient's jaw 3 months after the treatment

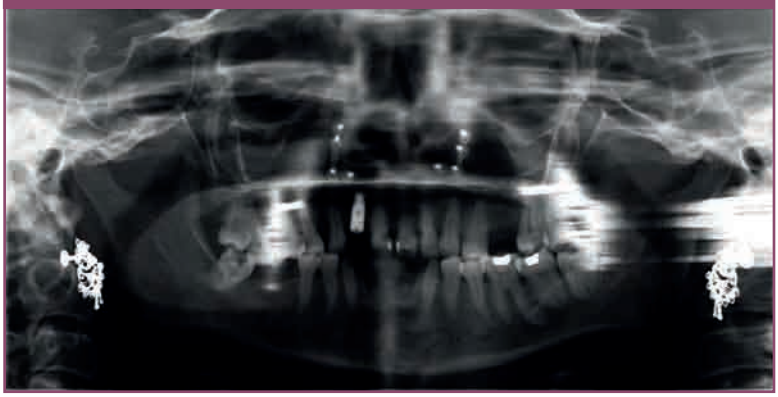
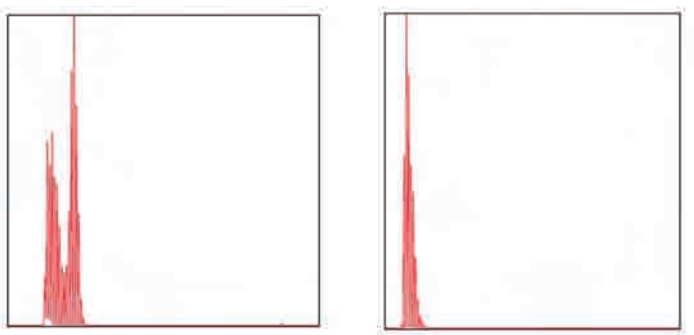
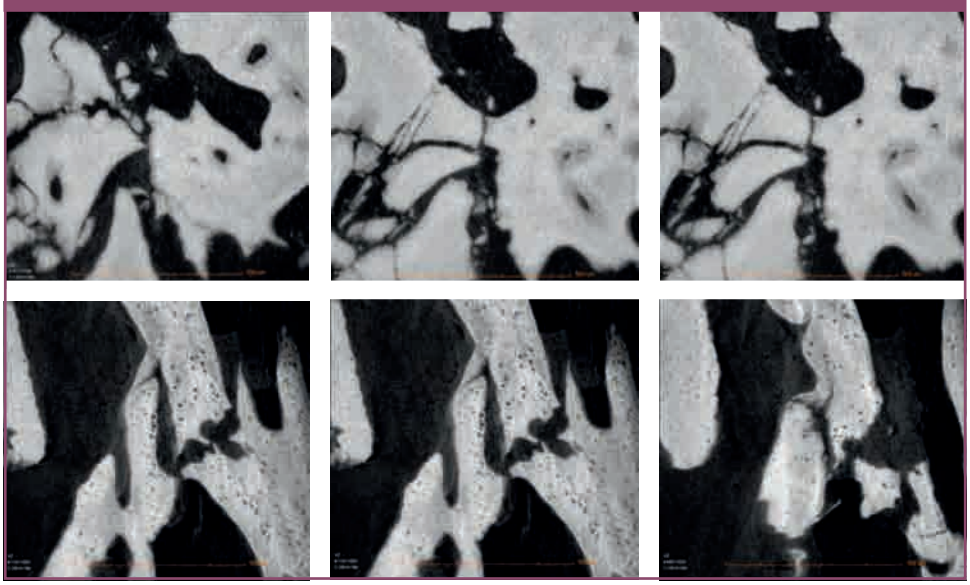


Figure 4: Histogram of the gray level distribution in a (a) socket 31 (grafted with a Xenograft)and 41 (treated with PLGA scaffold) 3 months after extraction in patient 1

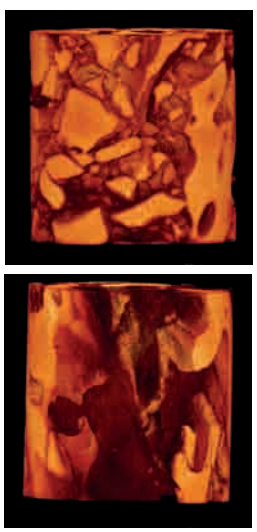


a) (Standard Deviation= 11.033) b) (Standard Deviation= 3.49)

Figure 5: Images on the top rows are CT slices of bone sample retrieved from socket grafted with Xenograft showing a lack of new bone growth while images in the bottom row shows new bone regeneration through evidence of osteocytes, which the lighter regions shows compacted mineralized bones in the sample extracted from the socket preserved using Bioscaffold.



Figures 6 a & b: 3D render image comparing (a) Xenograft (left) and (b) Bioscaffold (right). There is greater presence of soft tissues in the bone sample treated with Bioscaffold

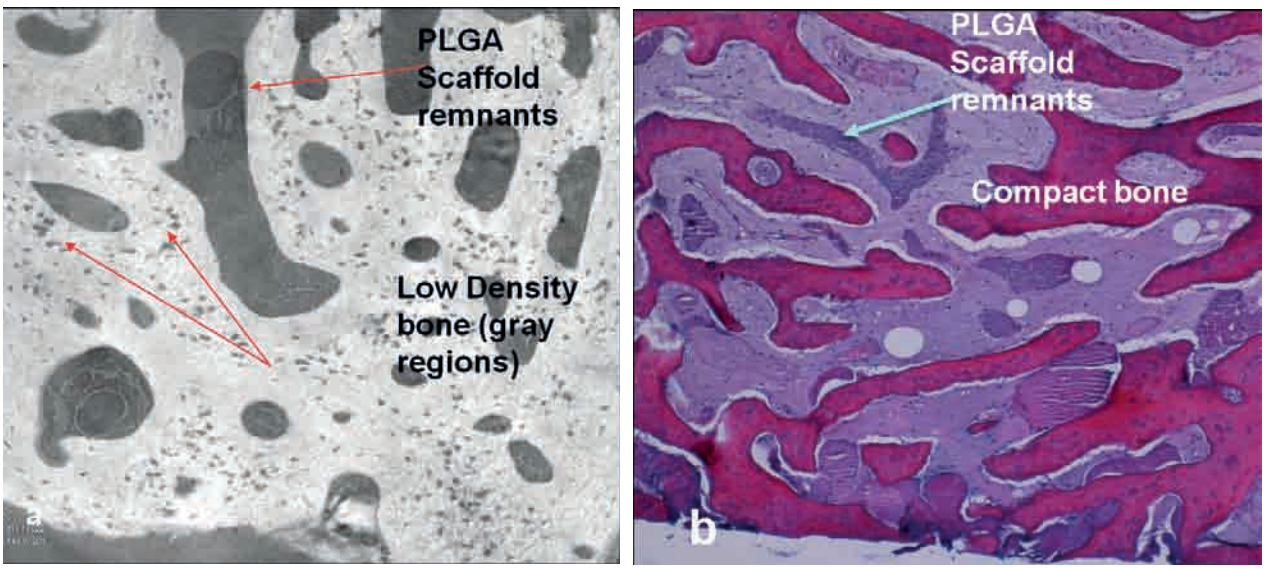


a)

b)

Figure 7: Micro CT 3D image of Bioscaffold regenerated bone sample @ 1 µm resolution

Figure 8: Micro CT slice of bone sample @ 1 µm resolution, compared with conventional histology.



than the conventional histopathology. In addition to it, the Micro CT is able to distinguish between the type of bone and stages of healing when different grafting materials were used. In addition to this, the power of 3D Micro CT is its ability to render 3D image with clear indication of bone density distribution and soft tissue presence across the three dimensions which is not possible with conventional histology.

Conclusion

From the above figures and discussion, the following conclusions can be drawn:

1. Synthetic Bio-scaffold is able to better assist the natural healing process.
2. Treating the socket with Bioscaffold results in natural healing within the given time frame with better bone quality.
3. Gray level analysis on the digital OPG is able to provide more information on the healing pattern in the socket but needs in depth analysis to conclude on the pattern of healing.
4. Micro CT provides a good insight in to the bone healing and the bone quality in three dimensions, compared to conventional histopathology. **DA**

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About the Authors

Dr. R. Gunaseelan has, over 20 years of experience in the areas of Dental Implants, Facial Deformity Correction, Temporo Mandibular Joint surgery, Cleft Lip & Palate Management, and Oral Pre-cancer treatment. He has delivered many key note lectures and has several international publications to his credit. In addition, the prestigious Royal College of Surgeons, Edinburgh has appointed Dr Gunaseelan to its panel of examiners for the Diploma in Implant Dentistry examination.

Dr. Praveen has over 25 years of experience in Dentistry, and is specialised in oral maxillofacial surgery. He has extensive hands on experience and training in advanced procedures like sinus lift, bone grafts and bone splitting and bone condensation techniques for GBR. Also in the use of different types of membranes for GTR and is skilled in all minor oral surgical procedures both under GA and LA, extra oral and intra oral procedures.

Dr. Margam Chandrasekaran is currently the Chief Scientist of Bio-Scaffold International Pte Ltd responsible for R&D process, new product and regulatory approvals. He has more than 18 years of research experience in various fields of engineering including processing of bio-materials and published more than 100 papers in referred International journals and conferences. He has also co-authored two books for Imperial College Press and joint-editor for series on bio-engineering and bio-materials by Imperial College Press.

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