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DETECTION OF BONE DEPOSITION ON THE SURFACE OF IMMEDIATELY REMOVED OR LEFT MINI-SCREW AFTER CANINE RETRACTION (SEM STUDY)

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Abstract:

Objective:

The aim of the study is to detect the changes happed on the surface of the mini-screw regarding bone deposition and ions deposited on the surface after retraction of the canine tooth.

Patient and method: This study was performed over 10 patients, each one received 2 machined titanium mini-screws in the upper arch between the first molar and second premolar for retraction of canine tooth. After retraction of canine the left side was removed (group 1) and the right side was left in place unloaded until treatment finished then removed (group 2) . The two groups were transferred for scanning electron microscopy to analyze the changes happened on the surface regarding bone and ions deposited on the surface.

Results: group 2 samples showed huge differences than group 1 regarding bone deposition on the surface and deposition of calcium and phosphorus ions. Group 2 showed higher bone deposition (3.466 %) than group 1 (0.034%), and in group 2 higher calcium and phosphorous deposition which equal 3.754 , 2.954 mass% respectively than calcium and phosphorus in group 1 which equal 1.949 , 1.606 mass % respectively.

Conclusion: using titanium alloy mini-screws for a long term contact with the bone and body fluids result in alteration on the surface, calcium and phosphorus deposition and randomly organized bony tissue osteointegrated on the surface in spite of smoother surface. This bony tissue formation might be enhanced by extended period of retention of mini-screw inside the alveolar bone.

Keywords: *mini-screw, surface changes, bone deposition, calcium and phosphorus deposition.*

Introduction:

Temporary anchorage devices (TADs) such as mini-screw act as skeletal anchorage for different orthodontic movements. Mini-screws are used when absolute anchorage is mandatory. These devices are widely used in Orthodontics offering excellent results and solving anchorage problems that could not be addressed previously. [9]

Despite all the advantages of the mini-implants, there is a small present of the placed mini-implants show failure and loosening due to inaccurate bone support for mechanical retention or fracture during their removal [1]. The fracture may be due to partial osteointegration of mini-screw when left in contact with bone for a long period or due to roughness of the surface that promote osteointegration of bone on the surface of the mini-screw.

Recent previous study showed, higher

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mechanical strength of stainless steel mini-screw than titanium mini-screw [3]. This result let us consider the risk occurred on titanium mini-screw during removal if bone osteointegrated on the surface.

Previous experimental animal study[15] showed no difference between loaded and unloaded mini-screws regarding the removal torque in the first month of healing period , but showed higher removal torque after 3 months unloading healing period . Another previous study [11] showed more bone deposition in loading mini-screw than unloading mini-screw. So, this finding leads us to an interesting point of research.

Accordingly, assessment of the effect of loading and unloading period on the surface of immediately removed and delayed removed mini-screws on the deposition of bone on the surface after removed from the patient mouth by using scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS).

Patient and methods:

The study was approved by the Research Ethics Committee of the Faculty of Dentistry, Minia University, Egypt. All the procedures were explained to the patients. An informed consent was signed by the patients.

Selection criteria for the patient:

The selected patients should fulfill the following criteria:

- Free from any systemic disease.

- Did not take any medication that affects the bone quality.

- No previous orthodontic treatment was carried out.

-The patient have class 1 molar relationship according to angle's classification with sever crowding or bi-maxillary protrusion that need absolute anchorage for retraction of canine teeth.

- Normal vertical dimension in all cases were included

Selection criteria for mini-screw:

- Mini-screws were selected from same brand and same material (titanium alloy, machined).

- The screws length were selected to be higher than 1.5 mm, 8 mm in length

Orthodontic treatment:

-Brackets were bonded in the correct position.

- Leveling and alignment were performed till reaching heavy stainless steel wire (0.017 x 0.025).

- First bicuspids were extracted.

- After one week, the mini-screws were inserted

- Thereafter, canine retraction was started.

Application of mini-screw:

Before mini-screw was inserted the patient was instructed to rinse the mouth by 0.2% chlorhexidine mouthwash and continued one week after mini-screw insertion to decrease the bacterial load around the mini-screw. X-ray was taken before mini-screw insertion to show the available space between the roots of second premolar and first molar and evaluate the parallelism of the roots. The self-drilling mini-screws were placed by expert clinician after injection of few drops of anesthetic solution. The mini-screw was inserted into the buccal-attached gingiva just adjacent to the mucogingival junction and

midpoint between the roots of the second premolar and the permanent first molar perpendicular to buccal bone until the cortex was penetrated and then gradually changes the direction during drilling of the screw into 45 degree in relation to the buccal surface.

Loading the mini-screw (canine retraction):

-Retraction was carried out using power chain between the canine and mini-screw.

-The force amount was 150 gram, determined by a force gauge.

Miniscrew removal:

After canine was retracted the first loaded screw was removed immediately and the second unloaded screws were removed after 4 months or close to treatment finish, all screws were removed carefully and slowly to prevent any risks during screw removal. The removed mini-screws were transferred for fixative solution (a mixture of formaldehyde and glutaraldehyde) before scanning under electron microscopy. The samples were scanned after one week from removal under scanning electron microscopy (SEM).

Energy dispersive spectroscopy (EDS) analysis was used to measure the elemental composition of bone-like structure specially the calcium (Ca) and phosphorous (p), as the calcium and phosphorus is an important ions for bone tissue formation [5]

Scanning electron microscopy:

All mini-screws were dried in a desiccator for removing moisture from specimens, then all the screws was coated with the gold to enhance the image taken for the surfaces and then examined under SEM (JEOL : JSM-IT200). Mini-screw body was scanned under fixed magnification (x33) and multiple images were taken for different surfaces that show bone-like structure deposition with higher magnification.

Image J software was used to measure the amount of bone-like structure deposited on the surface. The surface area of the tissue deposited of group 1 was compared to group 2

Results:

Scanning electron microscopy:

SEM images were taken for of the surfaces of the samples from the two groups as shown in (figure: 1). There was change in the surface roughness between the two groups, the second group showed increase in the roughness, more debris and huge formation of bone like- tissue on the second group(figure: 2, 3) than group 1.

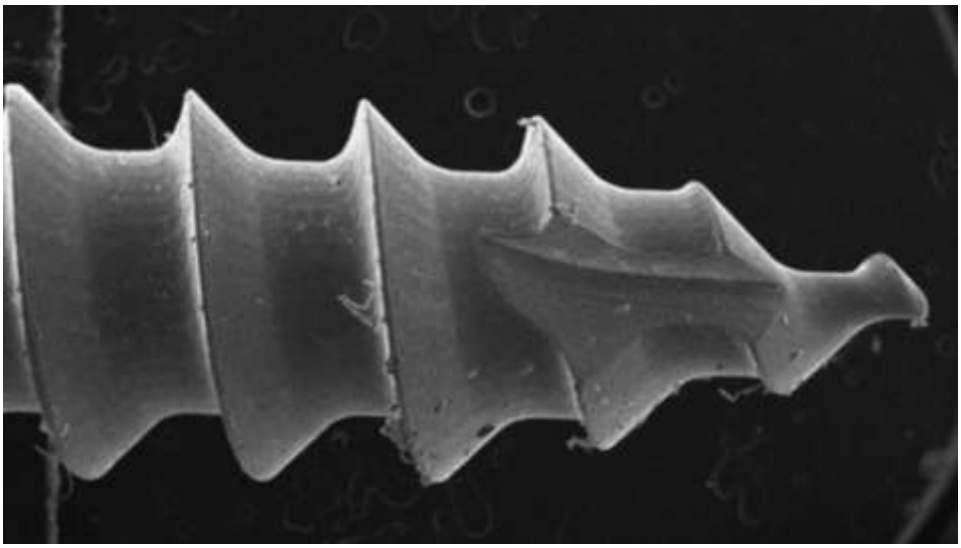

fig: 1

Group 1: (figure 1) scanning electron microscopic image under fixed magnification X33 for immediately loaded group that was removed immediately after canine retraction.

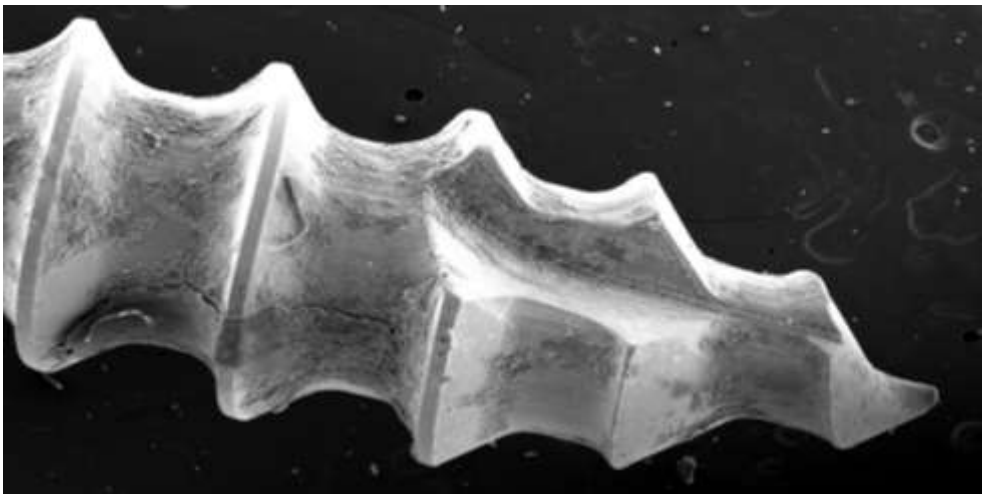

Fig: 2

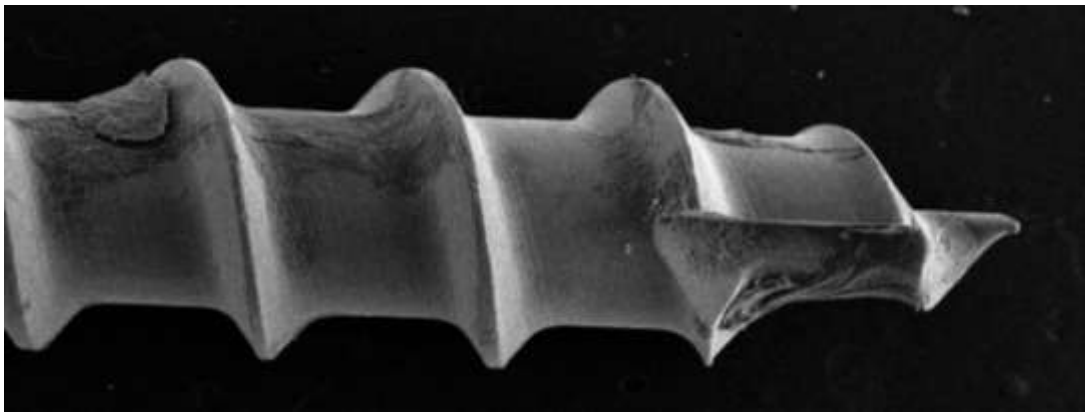

Fig: 3
group 2 : (figure 2 – figure 3) scanning electron microscopic images under fixed magnification X33 for immediately loaded group that was left in place until treatment finished.

There was bone-like structure on the surface in most of the samples from group 2, it is assumed to be a bony tissue deposited haphazardly on the surface of different parts of the mini-screw.

A higher magnification SEM images(x 350 – x 4500) were taken to some area in the screw body or the tip that showed bone deposition on group 2 samples, changes in the surface properties as pitting of the surface, and there were a tissues adhere to the surface it is assumed to be a more bone osteointegrated to the surface when left unloaded inside the mouth until treatment finished

The surface area of the bone-like structure in the two groups was measured in μm by using Image-J software , group 2 showed higher surface area of bone-like tissue deposited on the surface than group 1 in relation to the total surface of the screw as in (fig:4-5). There was a statistically significant difference between 2 groups regarding bone deposited on the surface as shown in table1, figure 5.

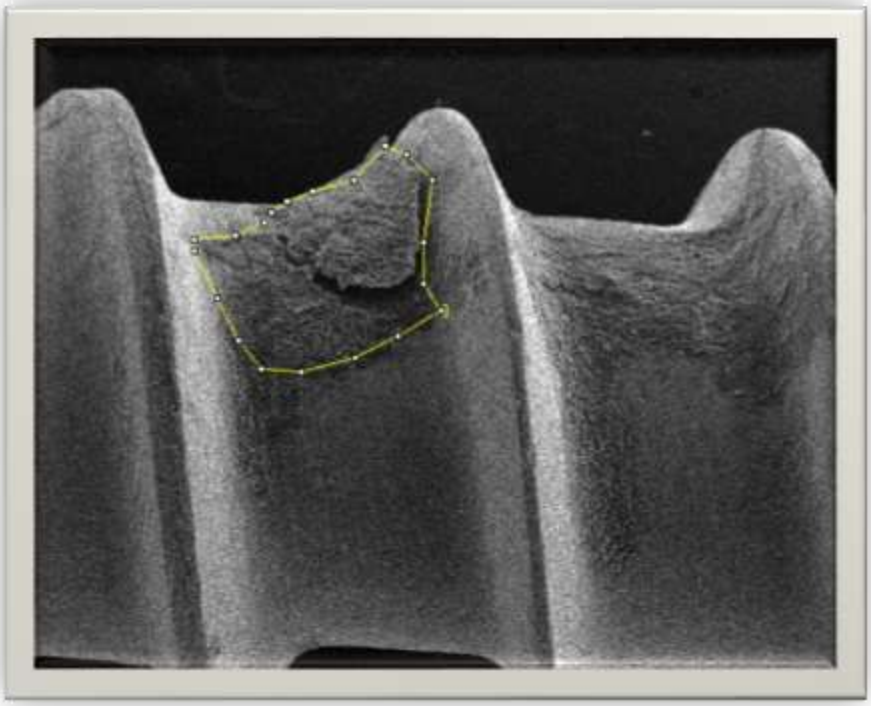

Fig: 4

Volume of bone deposition in percentage	Group I	Group II
Range	0.0311-0.0387	2.2862-5.6946
Mean	0.0340	3.4663
S.D.	0.0025	1.2541
T	45.25	
P	0.0001*	

- **Table (1): Comparison between the two studied groups regarding Volume of bone deposition in percentage.(Independent Samples T test for quantitative data between the two groups)**

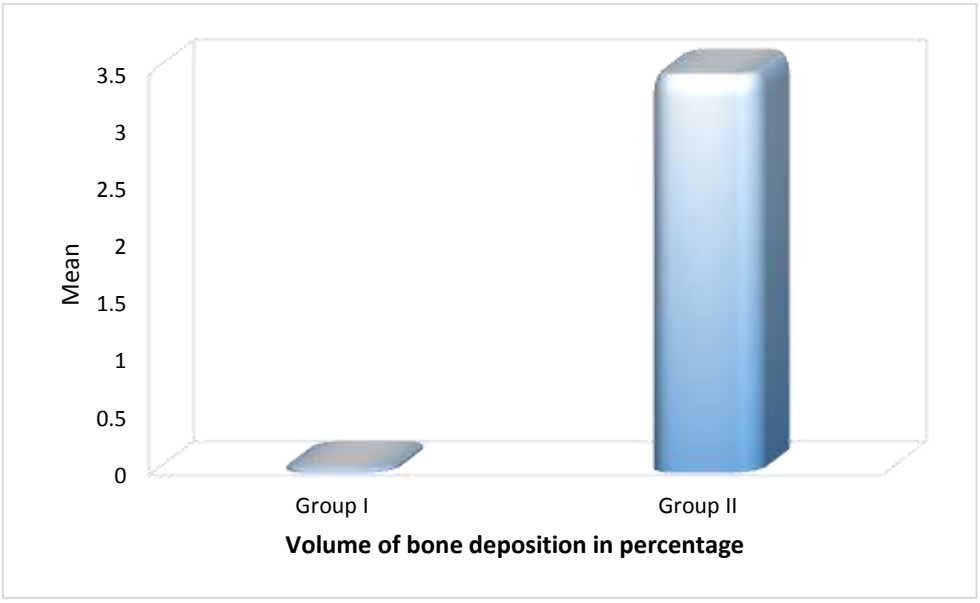

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Figure (5): Comparison between the two studied groups regarding -

Volume of bone deposition in percentage.

Energy dispersive spectroscopy (EDS) analysis:

Analysis of the mini-screw body and tip showed Calcium and phosphorus was found higher in the second group than the first group which is assumed to be due to the bony tissue deposited on the surface, there was statistically significant difference between the two groups as shown in table (2, 3) and figure (6-7).

Calcium	Group I	Group II
Range	1.25-2.85	3.1-4.08
Mean	1.949	3.754
S.D.	0.58	0.36
T	19.58	
P	0.001*	

Table (2): Comparison between the two studied groups regarding calcium.

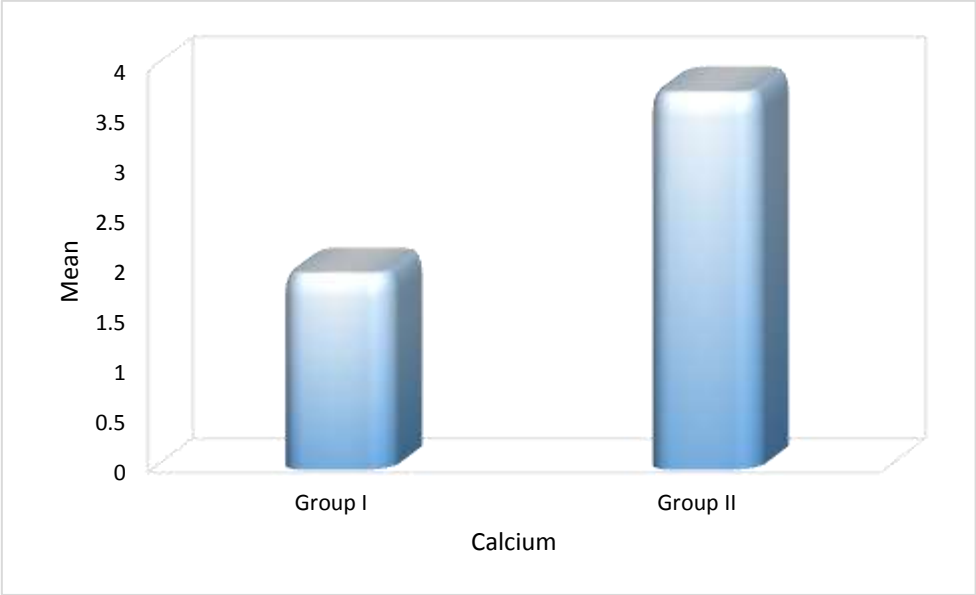

Figure (6): Comparison between the two studied groups regarding calcium.

Phosphorus	Group I	Group II
Range	1.26-1.98	2.5-3.2
Mean	1.606	2.954
S.D.	0.22	0.26
T	18.52	
P	0.001*	

Table (3): Comparison between the two studied groups regarding phosphorus.

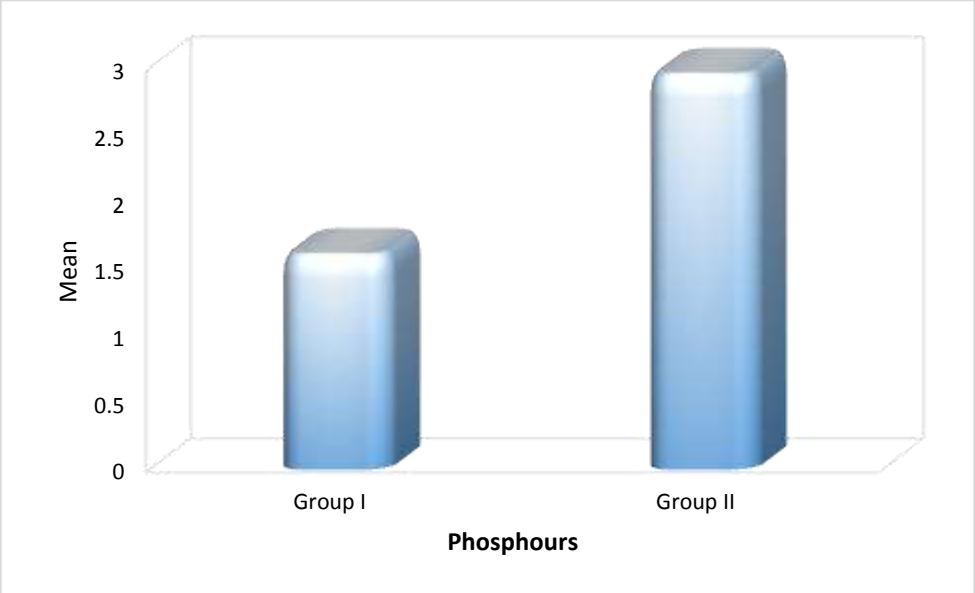

Figure (7) Comparison between the two studied groups regarding phosphorus.

Discussion:

Using of skeletal anchorage devices, also called, temporary anchorage devices (TADs), as mini-screw allowed wide range of tooth movement and less anchorage loss with higher success rate as stated by, **Büchter et al 2005, Lobb et al 2006.**[2], [12]. These studies showed the higher success rate of mini-screw as an orthodontic anchorage.

Mini-screws were selected from the same material (Titanium alloy) to decrease the risk of bias and because it is the most commercially available material in the market.

The screw diameter and length were selected according to **Hong et al (2016)** [14] study to be higher than 1.5mm in diameter and 8 mm in length. This study found the higher failure rated in diameters lower than 1.5 mm and length lower than 8 mm.

The force that was applied for the canine teeth and the mini-screw was equal in both sides. It ranged about 150 gm of force according to **Mezomo et al (2011),** [13] who showed that, the optimal forces for retraction of canine and loading the mini-screw were between 100-200 gm.

The patients were instructed to rinse by chlorhexidine during the healing period to decrease the inflammation as stated by **Lambert. et al 1997.** They claimed that, the chlorhexidine was effective in decreasing the bacterial load around mini-screw during the healing period. [10]

A mixture of glutaraldehyde and formaldehyde (4G: 1F) was used according to **Kiernan et al 2000** [8]. This mixture proved to be the best solution for preservation of the living tissue for one month.

Self-drilling mini-screws were used for more contact between the surface and bone to decrease the failure of mini-screw during servis as stated by **Chen et al 2008.**[4] they observed more bone deposition around self-drilling mini-

screw higher than bone deposition around self-tapping. In addition higher bone to implant contact was shown in self-drilling mini-screw than self-tapping mini- screw.

Many studies examined the process of osteointegration on different surface characteristics. Machined mini-screw has a smoother surface more than surface treated to enhance the osteointegration which lead to better mini-screw stability as stated by **Ikeda et al 2011.** [7] More bone deposition was observed on the surface treated than machined surface in animal study. In the current study, the machined mini-screw was selected as it is highly recommended in orthodontic practices to show the changes on the surface after different period, as well as loaded and unloaded.

The strength of the titanium alloy mini-screw is lower than stainless steel mini-screws as stated by, **Barros et al 2021.**[3] They claimed that a higher mechanical strength of stainless steel mini-screw was showed than titanium alloy mini-screw. The differences between the titanium alloy and stainless steel mini-screws regarding the torsional fracture and flexural strength were measured by especially fabricated device in their study [3]. If the titanium alloy mini-screw is strongly inserted by a higher insertion force, this might affect the mechanical properties of the mini-screw and put a risk on mini-screw during removal. So, osteointegration of bone on the surface might put a risk on mini-screw during removal as screw fracture. This result let us consider the changes occurred upon the surface of the titanium alloy mini-screw when left in place unloaded after orthodontic purpose from it was achieved.

Results indicated that long term retained unloaded mini-screw in contact with bone and body fluids, showed obvious changes in the surface of mini-screw including surface roughness, deposition of calcium and phosphorus and formation of bone-like tissue structure deposited on the surface. It was assumed to be a bone tissue or calcified structure. The results matched with **Eliades et al (2009)** [6] results. A lot of ions deposition, as the calcium and phosphorus and formation of calcified structure like bone particles on the surface of long retained mini-screws was detected.

The result of the current study showed more Ca, P and more bone deposition in the second unloaded group than first loaded one. These results were different from **Catharino et al 2014** [5] results. They concluded that amount of osteointegration depends on the time of contact between the bone and the surface of the screw. There was no significant difference between the loaded and unloaded mini-screws. Another histological study conducted by **Zhang et al 2010**[11] is also in disagreement with the current results.it showed the process of Osseo-integration was started between the mini-screw surfaces and the bone after healing period (0, 2, 4 and 8 weeks) and increased through contact time with the bone.

According to the result of the study it is better to remove the titanium alloy mini-screw as soon as the benefit from it was achieved to prevent the risk occurred upon it as, screw fracture especially the titanium alloy mini-screw has lower strength than other material.

Conclusion:

The results from analyzing the mini-screws in the two groups revealed the following conclusions:

1- Bone deposition on the surface increased in unloaded group than loaded group.

2- Higher deposition of calcium and phosphorus ions in group 2 than group 1 was detected which might be an indicator for the formation of osteoid tissue.

3- Leaving the mini-screw in place for more than 6 month might put a risk on the screw as changes in the surface characteristics and more bone osteointegrated on the surface in spite of the smoother screw surface. This might lead to screw fracture during removal,

4- It is better to remove the screw as soon as it is role was finished.

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