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Estimating the Stability of Orthodontic Micro-implant after Applying Orthodontic Force "An Experimental in Vivo Study"

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الخلاصة

الأهدف: لتقييم ثبات الزريعات التقويمية او تخلخلها عند تطبيق القوة التقويمية خلال فترات شفاء مختلفة (تحميل فوري، تحميل بعد اسبوعين وبعد اربع اسابيع). **المواد و طرائق العمل**: ثلاثون زريعة تقويمية غرست في ٦ ارانب. قسمت الارانب الى ثلاث مجموعات (٢ في كل مجموعة). المجموعة الاولى استقبلت تحميل مباشر بعد الغرس. المجموعتان الثانية والثالثة استقبلت التحميل بعد اسبوعان و اربع اسابيع من الشفاء على التوالي.تم قياس ثبات هذه الزريعات باستخدام جهاز (Periotest) قبل و بعد التحميل. حللت النتائج باستخدام الاحصاء الوصفي، تحليل التباين (ANOVA)، اختبار"دنكن" و اختبار "t". **النتائج**: من بين المجموعات الثلاثة، اظهرت المجموعة الاولى من الزريعات اكبر ثبات فورا قبل و بعد الغرس وبعد اسبوعان من فترة التحميل. **الاستنتاجات**: يمكن تحميل الزريعات التقويمية مباشرة بعد زراعتها بقوة تقويمية خفيفة ويمكن تحميل هذه الزريعات بعد ٤ اسابيع من فترة الشفاء.

ABSTRACT

Aims: To evaluate weather micro-screw implants remain stationary or move against orthodontic forces during different healing periods (immediate loading, loading after 2 weeks and 4 weeks). **Materials and Methods:** Thirty micro-screw implants were implanted in 6 rabbits. These rabbits divided into 3 groups (2 in each group). The first group received loading immediaty after implantation. The second and third groups received loading after 2 weeks and 4 weeks of healing period respectively. The stability of these implants was measured using periotest device before and after loading. The data was analyzed using descriptive statistic, Analysis of variance (ANOVA), Duncan Multiple analysis range test and student t-test. **Result:** Among th**e** three groups, the first group having a significant greater stability of micro-screw implants immediately before and after loading and after 2 weeks of loading period. **Conclusion:** micro-screw implants can be loaded immediately after implantation with light orthodontic force; also these implants can be loaded after 4 weeks of healing period.
Key words: micro-screw implant, stability.

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INTRODUCTION

Anchorage in orthodontics has been defined as the nature and degree of resistance to displacement offered by an anatomic unit when used for the purpose of performing tooth movement.[1] In many orthodontic cases, proper anchorage crucial for a successful treatment outcome. Skeletal anchorage provided by orthodontic mini-implant has attracted great attention in recent years.[2] These are prefer because of their small size, small diameter, minimal surgical trauma and low cost.[3] The retention of mini-implant is an important factor for improving the success rate of orthodontic treatment, retention depends on many factors such as implant type and dimension,[4] implant surface characteristic,[5] insertion torque,[6] force magnitude,[7] location,[8] bone quality.[9] Another important parameter which plays role in mini-implant retention to bone is primary stability is called the mini- implant stability immediately after insertion

in bone due to mechanical contact between implant and bone interfaces.[10] Whereas secondary stability develops because of bone remodeling processes and is the implant stability due to Osseo integration. [11]

This study addresses the following points: Is mechanical retention sufficient for the orthodontic anchorage or do osseo integration helps? Is immediate loading preferable or it is better to delay loading to allow for healing time after implantation?

MATERIALS AND METHODS

Six rabbits were used in this study. The experimental device was 30 micro-screw implants (MSIs) (AbsoAnchor System, Dentos, Inc., Daegu, Korea) (1.3 mm diameter, 5mm length) divided into three groups equally. The rabbits were divided into three groups; the first group (including two rabbits implanted with MSIs and subjected to immediate loading (100g of force) using NiTi closed -coil spring (Dentarum). The second group (including 2 rabbits) implanted with MSIs and subjected to the same force after two weeks from implantation. The third group (including 2 rabbits) implanted with MSIs and subjected to the same force after four weeks from implantation. The MSIs mobility of all was measured before and after force application for all groups using a periotest device (Medizintechnik gulden e.k. Eschenweg 3،64397 modautal, Germany) and this is done by holding the tip of the instrument's hand piece as horizontal as possible to the bone surface as shown in Figure (1)

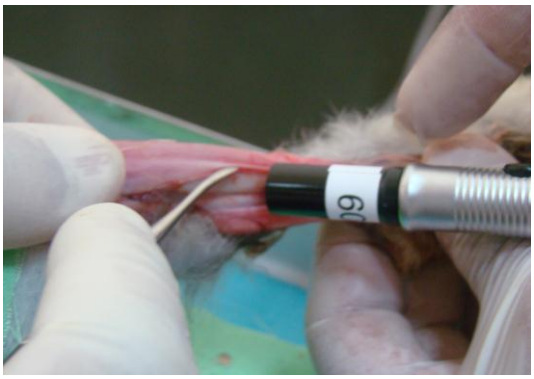

Figure (1): Periotest hold parallel to bone surface

According to the manufacture instructions, the value above (10) periotest units were associated with Osseo integration failure.

Surgical procedures: All operations were conducted under sterile conditions. The animals were anaesthetized intramuscularly with ketamine (44 mg/kg) and xylozine (7mg/kg). The internal surface of tibia was further blocked with 0.5ml of 2% lidocaine (Figure 2).

Figure (2): Local anesthesia to the tibia of rabbit

The tibia body was exposed (Figure 3).

Figure (3): Exposure tibia body

The cortical bone of the prepared sites was penetrated using a 6.0mm- diameter drill under profuse irrigation (Figure 4).

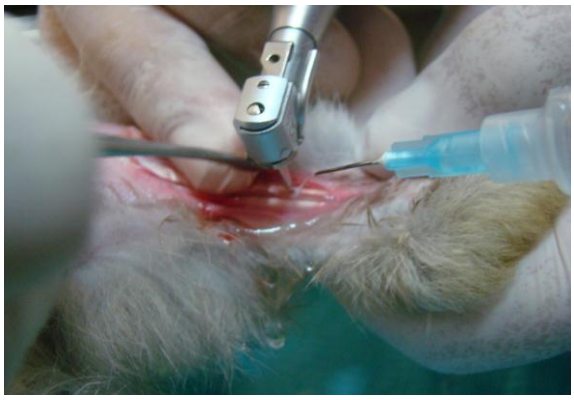

Figure (4): Penetration site of the drill

The micro-screw implant were placed using a manual driver, penetrating the cortical layer and going through the woven bone only (Figure 5)

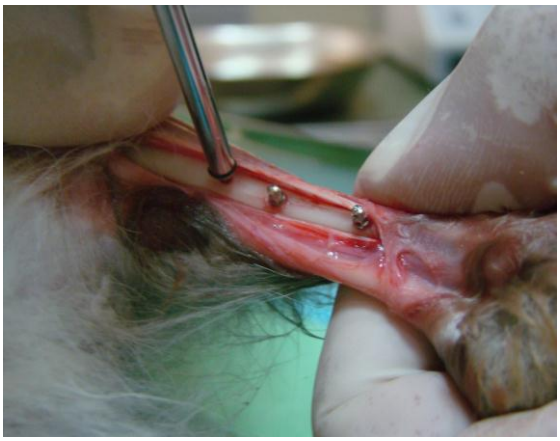

Figure (5): Implantation of the implant

then loading the micro screw implant with nickel titanium closed –coil spring applied to the coronal portion of MSIs with 100mg of force using tension gauge (Anthogyr company, francey) (Figures 6,7).

Figure (6): measuring the force by tension gauge

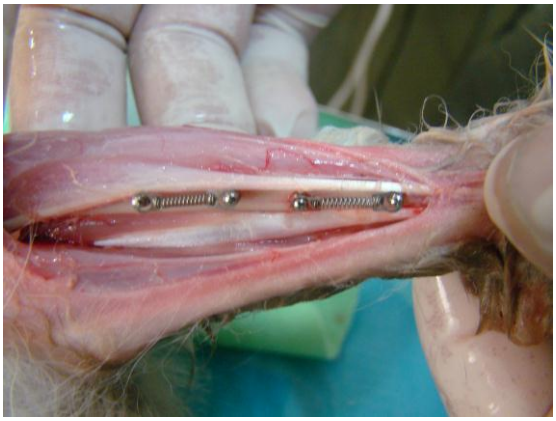

Figure (7): MSIs with closing coil spring

The mucoperiosteum and muscle were sutured using absorbable sutures (Figure 8).

Figure (8): tibia after suturing

The data was analyzed using Descriptive statistic, analysis of variance (ANOVA) at $p \leq 0.05$. These data were analyzed by Duncan multiple analysis range test to locate the significant differences among the groups and student t-test was also used.

RESULTS

The descriptive statistic, Duncan multiple analysis range test and F-value for the stability of MSIs of the three groups before loading were presented in Table (1).

Table (1): Descriptive statistic and ANOVA analysis and Duncan Multiple analysis Range test for the stability of three groups of MSIs before loading.

Variables*	Mean	±SD	F-value	Sig.	Duncan's group
Group I	0.60	0.126			A
Group II	1.0	0.0	39.0	0.000**	B
Group III	0.90	0.063			B

*Group I=MSIs subjected to immediate loading, Group II and III= MSIs subjected to loading after 2 and 4 weeks respectively; **= significant at $P \leq 0.05$.

There are a significant differences between group (I) and group (II, III) with the greater stability associated with the first group. For Table (2), descriptive statistic, Duncan multiple analysis range test and F-value for the stability of MSIs of the three groups after loading. Also, there is a significant difference between the three groups, with the first group having the greater stability.

Table (2): Descriptive statistic and ANOVA analysis and Duncan Multiple analysis Range test for the stability of three groups of MSIs after loading.

Variables	Period*	Mean	±SD	F-value	Sig.**	Duncan's group
Group I	0	0.716	0.160			A
Group II	1	1.0	0.0	15.235	0.000	B
Group III	2	0.966	0.051			B

*0= MSIs subjected to immediate loading, 1= MSIs subjected to loading after 2 weeks of healing period, 2 = MSIs subjected to loading after 4 weeks of healing period. **= significant at $P \leq 0.05$.

Table (3) shows the descriptive statistic, Duncan multiple analysis range test and F-value for the stability of MSIs of the three groups after 2 weeks of loading period. Although, there are no significant differences in the stability of the three groups, but the first group showed greater stability.

Table (3): Descriptive statistic and ANOVA analysis and Duncan Multiple analysis Range test for the stability of three groups of MSIs after 2 weeks of loading period.

Variables	Period*	Mean	±SD	F-value	Sig.	Duncan's group
Group I	0	0.916	0.040			A
Group II	1	0.983	0.098	2.745	0.096	A
Group III	2	0.883	0.075			A

*0= MSIs subjected to immediate loading and stability measured after 2 weeks of loading period, 1= MSIs subjected to loading after 2 weeks of healing period and stability measured after 2 weeks of loading period, 2 = MSIs subjected to loading after 4 weeks of healing period and stability measured after 2 weeks of loading period .

Tables (4) describe the descriptive statistic and student t-value for the stability of MSIs of the first group before and after 2 weeks of loading. There is a significant difference in the stability of MSIs with a greater stability immediately after MSIs implantation (before loading) when compared with stability after 2 weeks of loading period. Also, a significant greater stability of MSIs after immediate loading was observed when compared with stability after 2 weeks of loading period.

Table (4): Descriptive statistic and student *t*-test for the first group of MSIs before and after loading.

Period*	Mean	±SD	*t*-value	Sig.
0	0.6	0.126	-5.836	0.000**
1	0.916	0.040		
1	0.916	0.040	-2.963	0.014**
2	0.716	0.160		

*0= the stability of MSIs measured immediately before loading, 1=MSIs subjected to immediate loading and stability measured after 2 weeks of loading period, 2= the stability of MSIs measured immediately after loading. **= significant at $p \leq 0.05$.

Table (5) shows the descriptive statistic, Duncan multiple analysis range test and F-value for the stability of group II MSIs subjected to loading after 2 weeks of healing period, the stability of these MSIs measured immediately after implantation, after 2 weeks of healing period, and after 2 weeks of loading period. There is a significant difference in the stability with a greater stability after immediate implantation.

Table (5): Descriptive statistic and ANOVA analysis and Duncan Multiple analysis Range test for the stability of the second group of MSIs

Period*	Mean	±SD	F-value	Sig.	Duncan's group
0	0.850	0.054			A
1	1.0	0.0	9.605	0.002**	B
2	0.983	0.098			B

*0= MSIs subjected to loading and stability measure immediately after implantation, 1= the stability of MSIs measured after 2 weeks of healing period, 2= the stability of MSIs measured after 2 weeks of loading period. **= significant at $p \leq 0.05$.

Table (6) show the descriptive statistic, Duncan multiple analysis range test and F-value for the stability of group III MSIs subjected to loading after 4 weeks of healing period, the stability of these MSIs measured immediately after implantation, after 4 weeks of healing period, and after 2 weeks of loading period. Also, there is a significant difference among the three periods with a greater stability occur immediately after implantation, then after 2 weeks of loading period.

Table (6): Descriptive statistic and ANOVA analysis and Duncan Multiple analysis Range test for the stability of the third group of MSIs

Period*	Mean	±SD	F-value	Sig.	Duncan's group
0	0.783	0.147			A
1	0.966	0.051	5.065	0.021**	B
2	0.883	0.075			AB

*0= MSIs subjected to loading and stability measure immediately after implantation, 1= the stability of MSIs measured after 4 weeks of healing period, 2= the stability of MSIs measured after 2 weeks of loading period. **= significant at $p \leq 0.05$.

DISCUSSION

Since the early days of implant dentistry, conscience on loading protocol has been lacking. Only recently have research begun to make site and situation-specific loading time recommendation. Research has focused mainly on restorative implants and is only now begging to examine micro-screw implant loading and stability.

Immediate loading of MSIs is becoming more common, with several reports in the literature to support the practice.[12, 13] The result in this study showed that the immediate loading MSIs possessed the greater stability when compare with the other groups then there is a decreased in the stability of second group of MSIs and the stability was gradually recovered as

time passed in the third group of MSIs. It is supposed that the greater stability of the first group is due to mechanical retention (primary stability), then there is a temporary inflammatory reaction caused by insertion trauma and the gradual recovery by bone remodeling afterward. This result is supported by Chatzigianni [(14)] who stated that there is a critical period in terms of screw stability between primary and secondary stability, namely a period in which less new secondary stability is provided by bone formation than primary stability has been lost due to bone resorption. During this period, the MSIs are at a particular risk of premature loss. The same result can be seen when comparing the stability of MSIs within the groups, in which the greater stability was obtained during initial time of MSIs placement, then there is a decrease in the stability of MSIs and by time there is re increase in the stability of MSIs.

In this study, the MSIs can be loaded immediately with light orthodontic force which comes in agreement with other study. [(15, 16, 17, 18, 19)]

The healing period in this study was 2 weeks and 4 weeks and this may be considered as a short healing period and perhaps the effect of Osseo integration may become more obvious if we increase the healing period. Interestingly, Ohmae et al [(20)] stated that, the 6 weeks healing time may have been (too short to allow enough Osseo integrations" On the other hand, Roberts et al [(21)] stated that, a healing period up to 36 weeks in length was recommended.

Another important point in this study is that our study was carried out using rabbits and the osseo integration in rabbits was three times faster than in humans, [(22)] that means a 1 week healing period in rabbits is equivalent to 3 weeks healing period in humans which should be kept in mind when choosing the exact period for loading the MSIs on human bone.

CONCLUSIONS

Immediate loading with light orthodontic force provide stable MSIs due to mechanical retention. After 2 weeks of healing period, there is a reduction in the stability of MSIs so we do not recommend loading during this period. After 4 weeks of healing period, the implant-bone fixture is strong enough to support loading. Loading at that time is recommended.

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