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Original Research Article

In-vitro investigation of primary stability of orthodontic mini implants with different lengths using resonance frequency analysis

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ABSTRACT

Introduction: Out of various ways of gaining anchorage, mini implants are gaining attention due to its minimum compliance and maximum curative effects.Mini implants are considered successful if they have sufficient primary stability that comes from mechanical interlocking of mini implant with the bone.Factors which influence the implant stability are bone physiology, implant size, shape and surface characteristics. Considering all other factors within anatomic constraints, what may play a role in primary stability of mini implants is length. Literature search to correlate mini implant length with primary stability was found to be insufficient and hence this study was undertaken.

Materials and Methods : In this study, two goat jaws were subjected to spiral 3D CT scan and the areas with D2 bone density were identified and marked. In these D2 density marked areas, 30 implants of 1.5 x 6mm (GROUP A) and 30 implants of 1.5 x8mm (GROUP B) were placed. Their stability was measured by Radio Frequency Analysis using Osstell ISQ device with its Smart Peg. A connector was fabricated to make the fit of smart peg compatible with the head of mini implant. Readings were made in 5 different directions for each implant and their average value was considered as final reading.

Results: It was noted that primary mini implant stability is significantly higher (p 0.034) with GROUP B implants than with GROUP A implants.

Conclusion: The increased length of mini-implants positively affects its primary stability and should be taken into consideration when implants are used as anchorage devices.

1. Introduction

Anchorage is unrivalled for safer and less complicated tooth movement but is also a challenging task, resembling tug of war.[1] Anchorage can be gained extraorally or intraorally. Extraoral anchorage can be gained through cervical, occipital, parietal and zygomatic areas. Extraoral anchorage provides high anchorage value, but is dependent on patient compliance. Sources of intraoral anchorage units namely are teeth, muscles and underlying bone.[2] Anchor loss is a major problem in Orthodontics where atmost efforts are directed in controlling the loss. Keeping this fact in mind, Temporary Anchorage Devices have gained vital importance.[3] These mini implants are available in various designs, diameters and lengths designed to perform different functions at different sites in the oral cavity.[4]

The basic requirement for the success of orthodontic mini-implants is sufficient primary stability which comes from mechanical interlocking with the cortical bone when the mini-implant is placed.[5] Primary stability is influenced by bone quality and quantity, surgical technique, and screw geometry (design of the implant, its diameter and length).[6] Bone quality and quantity are important factors since they

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directly influence the selection of mini implant.

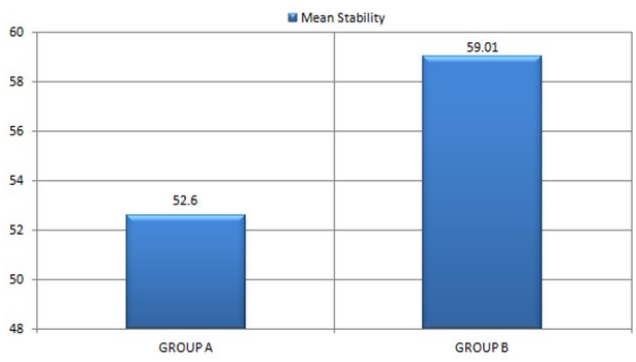
In 1988, Misch described five groups, based on macroscopic cortical and trabecular bone characteristics as D1, D2, D3, D4 and D5,[7] out of which D2 bone is found most commonly in the region where implant placement is most feasible.[8] It exhibited a 47%-68% greater ultimate compressive strength compared with D3 bone.[9]

Considering the factors such availability of interradicular bone, approximation of vital structures and root proximation, literature states that the recommended diameter of a mini-implant is 1.2 to 1.6 mm for safe placement in the alveolar bone.[10] Thus implants with exceeding diameters above 1.6 mm cannot be considered feasible for placement. Hence the length of the implant rather than the diameter can be looked upon for achieving good primary stability.

However literature search to correlate the effect of length on primary stability of implants was found to be inefficient.

Determining primary stability after insertion can help predict success of the orthodontic mini-implant. The methods used to clinically evaluate implant stability were the tapping method,[11] radiography,[12] and the Periotest.[13] All these methods have their own advantages and drawbacks. With advancement in technology, newer equipments are made available. Resonance Frequency Analysis (RFA) has proven to be an adequate method because of its non-invasiveness and contactless method to measure stability.[14]

Considering all the above statements, we found a scope to undertake a research to investigate if the changes in the length of mini-implant, keeping the diameter constant affect the primary stability in an animal bone with D2 density (density matched with human D2 bone using spiral 3D CT Scan) using Resonance Frequency Analysis.



Graph 1: Mean stability of mini implants

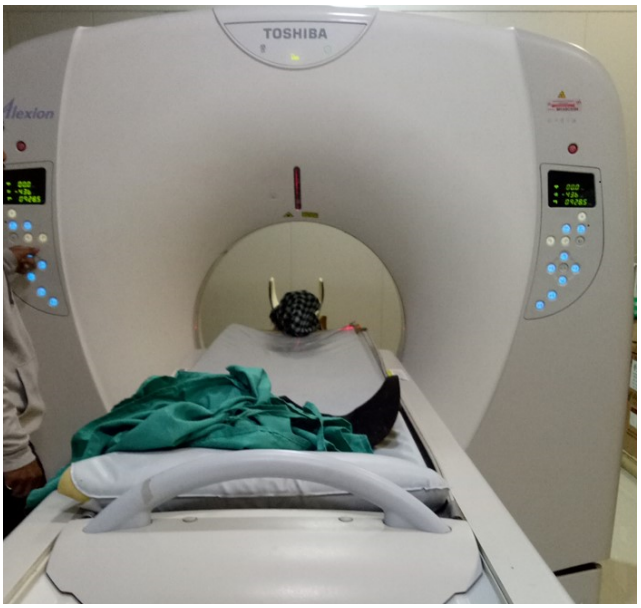


Figure 1: Goat jaw subjected to spiral 3-D CT scan for density matching

Figure 2: Goat head image subjected to spiral 3D CT Scan

Figure 3: Areas of D2 Density in hounsfield units (HF)

Figure 4: Jaw 1

Figure 5: Jaw 2

Figure 6: Ostell ISQ along with the armamentarium for implant placement and stability measurement.

Figure 7: Connector attached to smart peg

Figure 8: Primary stability of each implant measured using Osstell ISQ on Jaw 1

2. Materials and Methods

2.1. Materials

1. Fresh bone of animal sacrificed for meat purpose having density equivalent to D2 type human bone.
2. 60 Orthodontic mini implants of sizes (1.5×6mm and 1.5×8mm) 30 each (JSV system).
3. Customized smart peg attachment for mini implant.
4. Smart peg from Osstell.
5. Osstell's implant stability meter.

3. Methods

3.1. Inclusion criteria

1. Animal jaw bone with D2 density.
2. Implants with 1.5 mm diameter.

3.2. Implants with 6 mm and 8mm length.

1. JSV implants with implant driver.

3.3. Exclusion criteria

1. Animal jaw bone with density other than D2.

2. Implants with diameter other than 1.5 mm
3. Implants with length other than 6mm and 8mm.
4. Implants of system other than JSV.

3.4. Method

For this study, two goat jaws of freshly sacrificed animals (sacrificed for meat purpose) were subjected to spiral 3D CT scan for density matching (Figures 1 and 2 shows goat head image after the spiral 3D CT SCAN is completed.

The bone whose density matched with the D2 density of human bone was considered for the study. Figure 3 shows the areas of D2 Density in Hounsfield units(HF) i.e. 950 to 1250 HF.

The bone whose density matched with the D2 density of human bone was considered for the study. Figure 3 shows the areas of D2 Density in Hounsfield units (HF) i.e. 950 to 1250 HF. The remaining bone that did not match with D2 density was not included in the study.

The bone matching with D2 density was marked manually on both the goat jaws with marking pencil. It was done on either side of the jaws so as to make the placement of 30 implants possible in one jaw (Figure 4) & (Figure 5).

Table 1: Mini implant placement specifications

Jaw	Right side	Left side	Total no. of implants
Jaw 1	Group a (15)	Group b (15)	30
Jaw 2	Group b (15)	Group a (15)	30

For this study, implants of 1.5mm diameter with 6mm length were categorized under GROUP A and implants with 1.5 mm diameter with 8mm length were categorized under GROUP B. As tabulated in Table 1, 15 Group A mini Implants were inserted on right side of jaw 1 and 15 Group B mini implants were inserted on left side.The reversal of placement was done in jaw 2 so as to avoid bias. As a known research fact, implant insertion angle has a vital role in implant stability. Highest stability was found at insertion angles of $60^0$to 70^0. Keeping this in mind the mini implants were inserted at an approximate 70^0angle in the goat jaw. The placed implants were thereafter subjected to primary stability measurement using Osstell ISQ Implant Stability Meter. (Figure 6)

The Osstell stability meter is not compatible for mini-implants. In order to make it compatible, a connector (Figure 7) was customized to attach the implant with the smart peg.

To rule out bias, Implant placement was done by one person and primary stability of each implant was measured five times in five different directions namely right, left, front, back and up (to rule out bias) by another person (blind to the implant specifications in the bone), the mean of which was considered as final reading.(Figure 8)

30 Mini implants of 1.5 x 6mm with their 5 readings and average value were tabulated in master table. Another 30 implants with 1.5 x 8mm size were tabulated in similar manner.

4. Results

As our study had two independent variables i.e. two separate group of implants with different lengths and one dependent variable i.e. D2 density bone, Independent T- test was made the test of choice for statistical analysis. nd Graph 1 shows the mean stability and its comparison among all the samples in Group A (1.5 x 6mm) and Group B (1.5 x8 mm). The mean stability of the mini implants was 52.60 in Group A (1.5 x 6mm) and 59.01 for Group B (1.5 x8 mm). The standard deviation was found to be 10.37 and 6.93 for Group A (1.5 x 6mm) and Group B (1.5 x8 mm) respectively.

When subjected to independent T test, the difference in the mean stability among the studied groups was found to be statistically significant with p value 0.034.

It was noted that primary mini implant stability is significantly higher (p value 0.034) with GROUP B (1.5 x 8mm) implants (mean value 59.01) than with GROUP A (1.5 x 6 mm) implants (mean value 52.6).

5. Discussion

Anchorage is of utmost importance when planning orthodontic treatment. Out of various ways of gaining anchorage, mini implants are gaining attention due to its minimum compliance and maximum curative effects.[3] Mini implants are considered successful if they have sufficient primary stability. This primary stability comes from mechanical interlocking of threads of implants with the bone.[5] Also, there are various factors which influence the implant stability like insertion angle of implant in the bone, bone physiology, implant size and shape and implant surface characteristics.[6] Out of various bone densities, D2 bone was selected for conducting this study as it is found most commonly in the region where implants are placed in humans for orthodontic anchorage purpose. Mini implants are available in wide range of diameters and lengths. Considering the anatomic constraint, as orthodontic implants are placed inter-radicular, the diameter of the implants cannot be increased beyond certain limits. Keeping this in mind, out of this wide range, Titanium implants (Grade 5) with 1.5 mm diameter was selected for this study.[10] Thus the only factor that remains in an orthodontists hand to increase the stability of implant may be its length. This study was hence carried out keeping all the factors such as material, morphology and diameter of the implant constant within both the groups (experimental and control group). Literature search to find correlation between implant length and its effect on primary stability was found insufficient. Hence this study was undertaken.

The only factor altered was the length of the implants – group A consisted of Titanium implants of 1.5 mm diameter and 6 mm in length, whereas Group B consisted of Titanium implants of 1.5 mm diameter and 8 mm in length.

In this study, two goat jaws were collected from a Butcher which was freshly sacrificed for meat purpose. These jaws were subjected to spiral 3D CT scan and the areas with D2 Bone density were identified and marked on the goat jaws. In these D2 density marked areas, 30 implants of 1.5 x 6mm (GROUP A) and 30 implants of 1.5 x8mm (GROUP B) were placed. Their stability was measured by Radio Frequency Analysis using Osstell ISQ device with its smart peg. A connector was fabricated to make the fit of smart peg compatible with the head of mini implant. Readings were made in 5 different directions for each implant and their average value was considered as final reading.

The mean stability and standard deviation of Group A was 52.60 and 10.37 respectively whereas for group B it was 59.01 and 6.93 respectively. When subjected to statistical analysis (Independent T test) the results were found to be highly significant (p 0.034). The results suggest a high correlation of primary stability and length of the implant. Increase in the implant length merely by 2 mm increased the primary stability to a considerable value. The results of this study are in accordance with the study conducted by S.C. Mohlhenrich et al,[15] Heussen N et al.,[16] Athina Chatzigianni et al,[17] Nienkemper,[18] Pithon[19] and Sarul.[20] They concluded that primary stability increases with increase in length of mini implants.

However, the results of this study are in contrast with study done by Singh AK et al,[5] Song et al.[21] and Neinkemper et al.[22] They concluded that primary stability of mini implants is not affected by changes in length of mini implant. These differences in results found may be due to variation in brands of implants used,[5] or changes in diameter along with length of implants studied.[21] In this study, we selected constant diameter and brand for both the groups to prevent any changes in surface morphology, only factor that was altered was the length of the implants studied.

6. Conclusion

Anchorage simply means resistance to unwanted movement of teeth.[1,20] Out of various methods available to gain and reinforce anchorage, mini implants have gained utmost attention in recent years due to its versatility of use. For a successful implant placement, various factors are responsible namely bone physiology, anatomic variations at the site of implant placement, implant design and angle of mini implant placement i.e. insertion angle. Apart from diameter and surface morphology, what may play a role in primary stability of mini implants is length and hence this study was taken into account.

In this study, it was found that primary stability of mini implant significantly increases (p value 0.034) with increase in length of mini implant. When subjected to statistical analysis (Independent T test) the results were found to be highly significant (p 0.034). Thus the results of the study conclude that as alteration in diameter of the implant to be used is anatomically restrained due to close proximity of the implants with root structures of the adjacent teeth, length can be increased to increase the primary stability of the orthodontic mini implants.

However, it has to be kept in mind, that this study was conducted in an animal bone. Clinical conditions do vary, and simulation of all the clinical conditions in labs is impossible. Hence clinical studies in this field are warranted. Furthermore, this study has considered only one system of implants, more studies with different systems, lengths, diameter, insertion angle and surface morphology can be undertaken in future.

7. Source of Funding

None.

8. Conflict of Interest

None.

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