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Evaluation of stability of temporary anchorage devices for orthodontic treatment: A clinical study

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***Abstract*---**Aim: The purpose of the present research was to assess the stability of temporary anchorage devices used in orthodontic treatment. Methodology: Freshly ovine mandibles were cut in blocks. Twenty-seven miniscrews (diameter 1.6 × 8 mm; G2, Dual Top Anchor

System, Jeil Medical, Seoul, Korea) were inserted in the blocks and divided in 2 experimental groups: single miniscrew and the innovated design “Seifi Twin Screw (STS)”. Primary stability was evaluated by Periotest “M”® device. Results: Independent t-test showed a significant difference between 2 experimental groups in periotest evaluation ($p<$ 0.05). STS demonstrated higher primary stability due to its mechanical configuration and design. Conclusion: The STS provides higher primary stability and was found to be effective in increased success rate of miniscrew systems from the standpoint of primary stability.

***Keywords*---**Anchorage procedures, anchorage techniques, orthodontic anchorage procedures, miniscrews, temporary anchorage device.

Introduction

Stable Anchorage is one of the major factor in successful orthodontic treatment. Skeletal anchorage is used as one of the temporary anchorage devices (TAD), especially in complicated cases. Miniscrews are examples for skeletal anchorage which are used widely in different sites of mandible and maxilla.[1,2] They reduce the need for dental anchorage and can provide different tooth movements without patient’s cooperation. There are other advantages of miniscrews as TADs such as non-invasive insertion procedure, providing rigid anchorage against orthodontic loads and minimal anatomic limitation for placement.[2,3] However, there are still problems which have effects on the success rate of miniscrew-as sisted treatments. Because of immediate loading on orthodontic miniscrews, primary stability became a basic requirement for loading forces on miniscrews.[4,5] It is considered as clinical condition of miniscrew immobility and capacity to withstand loads in different directions.[6] The primary stability of miniscrews is mostly supported by mechanical retention between bone and miniscrew surface.[7,8] Primary stability is influenced by factors such as overloading [5], bone density [6,9-11], cortical bone thickness [12], screw design [13,14] and root proximity.[15] Studies about different variety of miniscrew designs to improve primary stability are increasing. Different changes in screw diameter, length and the design of the threads have been investigated.[16]

There are different methods to assess miniscrew primary stability. Measuring insertion torque, resonance frequency analysis (RFA) and periotest value (PTV). The force used to insert the implant is called insertion torque,[17] insertion torque is related to bone tissue, cortical bone thickness and bone density. Adequate insertion torque is an indicator of mini implant stability.[14] It should be as high to ensure stability and as low enough to prevent overcompression of the bone. Resonance frequency analysis is also another method for quantitative measurement of primary stability, RFA value is assessed by attaching a transducer directly to the implant.[18] In this device, a magnetic piece called “SmartPeg” is screwed on top of the implant head. A handpiece emits electromagnetic impulses to SmartPeg in order to detect the resonance frequency of SmartPeg implant unit.[4] A noninvasive device called periotest is used for

analysis of implant stability. This device originally developed to measure damping effect of periodontal ligament around natural tooth. The range of PTV depends on damping characteristic of periodontal ligament around tooth.[13] It can also assess the mobility of implants and it has been used to measure primary stability of orthodontic miniscrews. The periotest device (Medzintechnik Gulden, Modautal, Germany), produces a transient vibration by tapping the implant as a rod inside the periotest handpiece which is electromagnetically accelerated. The device shows a quantitative reading from -8 (clinically rigid) to +50 (very mobile). More negative PTV means more stability of the implant. Wireless Periotest device (Periotest "M") is the recent design introduced for measuring stability in implant and orthodontic miniscrew. It is easy to use in clinical approach and shows reasonable and reproducible results from implant-bone interface.[19] Hence the objective of our study is to introduce the innovated STS and evaluate the primary stability of it compared with conventional single miniscrew anchorage system by PTV measurements.

Aim of the present study

The purpose of the present research was to assess the stability of temporary anchorage devices used in orthodontic treatment.

Methodology

Freshly ovine mandibles were cut into 10 cm long pieces under profuse saline-solution cooling (legal permission was obtained from Institutional Review Board). A total of 18 bone blocks were prepared after removing soft tissue. To determine cortical bone thickness and trabecular bone density, each bone block was scanned by Cone Beam Computed Tomography (CBCT) unit. Twenty-seven self-drilling orthodontic miniscrews (diameter 1.6 × 8 mm; G2, Dual Top Anchor System were used. For single miniscrew group, one miniscrew was inserted perpendicular to the bone surface of each block assisted by hand-held screw driver. The primary stability measurement was conducted using the periotest "M"® device. According to the manufacturer, the tip of the periotest was placed perpendicular to the minis crew and was held approximately 2mm away from the miniscrew head. This device measures the time that the rod remains in contact with the miniscrew; shorter contact time indicates more stability of miniscrew. Values were detected three times for each sample and entered to Excel sheet for further analysis. Data were tested for normal distribution by Kolmogorov-Smirnov test. The independent t-test was performed for comparison of PTV between two experimental groups using statistical software SPSS.

Results

The Kolmogorov-Smirnov test showed normal distribution for the PTV values in both experimental groups (p=0.2). The independent t-test revealed significant difference between single screw and STS groups for PTV. The mean value of PTV in the innovated system was significantly higher than the single screw system (p=0.025). (Table 1) Based on results regarding increased stability in STS. A force distribution can be analyzed and compared between single screw system and STS. In STS, as we applied periotest's rod perpendicular to the long axis of miniscrew;

the horizontal retentive arm between screws transfers the force to the other miniscrew and it resists against displacement and caries out a part of the force. The maximum tension probably is decreased and increased stability results reduced micro movements of miniscrews due to periotest evaluation. In the other hand, when we applied force to the single miniscrew system, statically, the force is resisted by a triangular distribution around the center of rotation. In application of single miniscrew, maximized reaction is produced in top and bottom of the miniscrew body, which produces excessive tension to the surrounded bone and reduced stability.

Discussion

Like screws, the miniscrews were conceived to transform a torsional couple into a compression force.[20] The geometry of the screw thread, specifically the relationship between the thread depth and the pitch, expressed as the TSF, influences the resistance to extraction in a porous material (like bone) when the diameter and the material of the screw are known.

An increase in TSF, which can be achieved by increasing the thread depth or reducing the pitch, increases the resistance of the screw. Concerning miniscrews in particular, a recent study has stated that factors involved in the resistance to extraction and compression forces are the type of material, device diameter, length of thread, and shear strength of the material into which the screw is inserted.[21] Other studies showed that the pullout strength, a fundamental parameter for primary retention of TADs, is linked to bone density, volume, and cortical thickness. Numerous factors appear to determine miniscrew implantation success but are still subject to debate: factors linked to the operator (surgical technique), implant site anatomy (cortical thickness, bone density, and keratinized gingiva), biomechanics applied (quantity, duration, and vectors of the force applied), degree of peri-implantal inflamation, and type of screw (diameter and length.[22] The present study represents an innovated design for skeletal anchorage devices without any intervention to the miniscrew designed by the manufacturer. Tozlu et al., has created an apparatus (a miniscrew ring) which was placed at the neck of the screw. The mentioned study claimed that this ring is able to increase stability due to increasing surface contact of bone with miniscrew. It also has spines which resist from the loading forces; punching the tissue is required to insert spines. The innovated system of STS, has showed increased primary stability compared to a single miniscrew. Clinical cases will determine the feasibility of this system in practice and adequate data regarding the efficacy of the STS will be published in near future in conjunction with the available data. Further studies are needed to investigate stability overtime by applying different types of force on STS.

Conclusion

The innovated system of STS, has showed increased primary stability compared to a single miniscrew. The quantitative evaluations suggest that STS can be used as an advantageous skeletal anchorage device in orthodontic treatments.

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TABLES

Table 1- Evaluation of PTV in test groups

Test groups	Periotest value (PTV)	
	Mean (SD)	*p*-value
STS	-5.7032	0.2
Single	-4.3540	0.025