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Original Research

Stability & anchorage of different mini implants-an original research

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ABSTRACT:
Introduction: Skeletal anchorage with mini-implants has greatly broadened the treatment possibilities in surgery and orthodontics recently. To lower implant failure, it is wise to obtain satisfactory primary stability. The aim of this study was to quantitatively examine the impact of implant design and dimension on primary stability. **Material and Methods:** Forty-two iliac bone of porcine were made and embedded in resin. To assess the primary stability, we recognized insertion torques of the following miniimplants: Aarhus Screw, AbsoAnchor®, LOMAS, Micro-AnchorageSystem, ORLUS and Spider Screw®. In each bone, five Dual Top™ Screws were implanted for reference purposes to achieve comparability among the specimens. **Results:** We noted widespread variation in insertion torques and therefore primary stability, depending on mini-implant design and dimension; the great impact that mini-implant diameter has on insertion torques was mainly conspicuous. Conical mini-implants achieved higher primary stabilities than cylindrical designs. **Conclusions:** The diameter and design of the mini-implant thread have a characteristic impact on primary stability. Dependent on the region of insertion and local bone quality, the choice of the mini-implant design and size is crucial to establish sufficient primary stability.
Keywords: Stability, Mini-implants, Anchorage

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INTRODUCTION

Stable anchorage is the chief necessity for effective treatment. The anchorage quality of dental structures in adult patients is often insufficient due to a periodontically-compromised and reduced dentition [11].

Under such conditions skeletal anchorage, and especially mini-implants, have proven useful, thus broadening the treatment options in surgery and orthodontics, due in no small part to less dependence on patient compliance [8, 12, 18, 27, 28, 30]. Nevertheless, we should not be tolerating failure rates of 10–30% as described in the literature [3, 4, 7, 15,

23, 29]. The factors below are currently regarded as possible reasons for implant loss.
1. Application of excessive forces on the mini-implant [6, 29],
2. A large lever arm (thick mucosa) [6, 29],
3. Peri-implantitis when inserted in the unattached mucosa [7],
4. Insufficient primary stability [19, 24],
5. Bone damage at insertion (bone compression, bone overheating).

The latter phenomenon is familiar to us from dental implantology [5] and could explain the loss of mini-implants at very high insertion torques in the mandible. There is clinical evidence from dental implantology that an implant's primary stability irrefutably determines its prognosis, as do other factors such as bone quality and oral hygiene [13, 21, 26]. Implant stability immediately after insertion is called primary stability ("Press-fit"). The essential factors affecting implant primary stability are bone quality, implant design, and insertion modalities. Some authors recommend implant site preparation modalities and implant type selection based on the anticipated local bone quality [9, 25, 31]. In addition to histological evaluation, two non-invasive methods for determining implant stability are available: measurement of insertion and removal torques [14, 17, 20] and the resonance frequency analysis (RFA) by Osstell [22]. RFA is based on the frequency analysis of oscillations transmitted to an implant by a transducer (the "smart-peg") Nevertheless, this measurement method is currently not applicable for mini-implants (statement by manufacturer). Radiological examination and Periotest® (Medizintechnik Gulden, Modautal, Germany) deliver only insufficiently precise measurements [1, 2, 10, 16, 22]. In this study we tested different mini-implant designs and sizes to discover whether sufficient insertion torque and hence adequate primary stability is achievable. We also quantitatively evaluated the differences between a conical and a cylindrical thread design.

MATERIALS AND METHODS

The following twelve mini-implant types were evaluated in this study (Figure 1): – Aarhus Screw 1.5 × 9.6 mm and 2.0 × 9.6 mm (Medicon, Tuttlingen, Germany), – AbsoAnchor® SH 14-08 and SH 1413-08 (Dentos Inc., Taegu, Korea), – LOMAS 1.5 × 9 mm and 2.0 × 11 mm (Mondeal, Tuttlingen, Germany), – Micro-Anchorage-System 1.5 × 11 mm (Micerium S.p.A., Avegno, Italy), – ORLUS 1.8 × 8 mm (Ortholution, Seoul, Korea), – Spider Screw® 1.5 × 8 mm and 2 × 11 mm (HDC, Sarcedo, Italy), – Spider Screw® K1 1.5 × 8 mm and 1.5 × 10 mm (HDC, Sarcedo, Italy). The ilium of country pigs was chosen as bone model [31]. The compacta thicknesses of such bone segments are similar to human maxillary and mandibular bone (Figure 2). In total, 42 segments measuring 5 × 5 cm from the same ilium site were prepared and embedded under water cooling in resin (ProBase®; Ivoclar Vivadent, Schaan, Liechtenstein). A raster of 25 implantation sites with a minimum distance of 4 mm was marked on the bone segments, and pilot drilling were done using a bench drilling machine (Opti B 14 T, Rexon Europe, Hilden, Germany) at 915 rpm (Figure 3). We used the following drills: diameter 1.1 mm (tomas® system, Dentaurum, Ispringen, Germany) for all mini-implants with a diameter of 1.6 mm or less, and 1.3 mm (Dual Top™ System; Jeil Medical Corporation, Seoul, Korea) for those of larger diameter. The pre-drilling depth was set at 3 mm. The implants were then manually inserted vertically in the bone surface using the recommended handheld screwdriver up to a bone-implant collar distance of 0.7 mm. Dual Top™ mini-implants (1.6 × 8 mm) served as reference implants to determine any differences among the various bone qualities (Figure 4). Sixty insertions in all were examined for each mini-implant type. After the manual pre-insertion, final screwing by another 0.2 mm up to the definite insertion depth was done by the Robotic Measurement System (RMS). Main component of this measuring system is a precision robot RX60 (Stäubli Tec-Systems GmbH, Bayreuth, Germany) equipped with a precision potentiometer functioning as an angle sensor and torque sensor. The moment sensor was coupled with the mini-implant using the respective driver shaft. The analogue signals delivered by the sensors were digitized by the multi-channel measuring device Spider 8 and were stored in a personal computer.

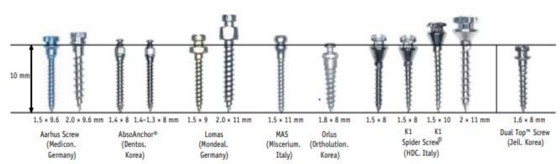

Figure 1. Tested mini-implants: Aarhus Screw 1.5 × 9.6 mm and 2.0 × 9.6 mm, AbsoAnchor® SH 14-08 and SH 1413-08, LOMAS 1.5 × 9 mm and 2.0 × 11 mm, Micro-Anchorage-System (MAS) 1.5 × 11 mm, ORLUS 1.8 × 8 mm, Spider Screw® 1.5 × 8 mm and 2 × 11 mm, Spider Screw® K1 1.5 × 8 mm and 1.5 × 10 mm as well as the reference implant Dual Top™ 1.6 × 8 mm.

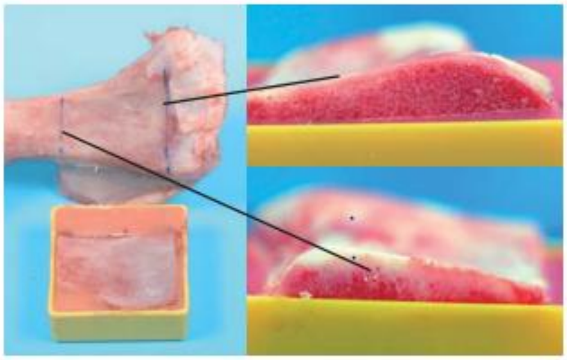

Figure 2. Prepared segment of the ilium of a country pig (on the left). The compacta thickness of the bone segments ranged from 0.5 mm to 1 mm towards the iliosacral joint (above right) and up to 3.0 mm towards the hip joint (below right).

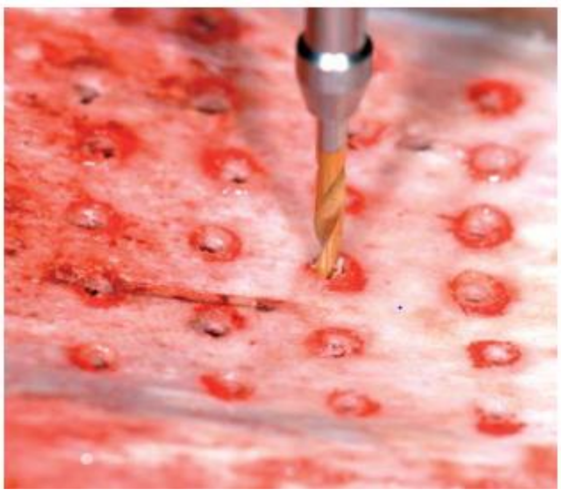

Figure 3. Insertion raster with the pre-drilling and implantation sites.

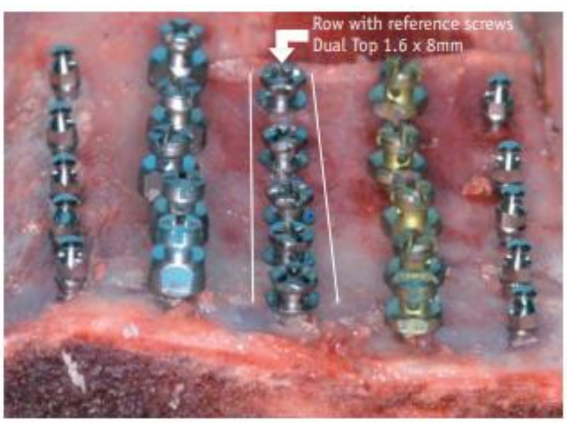

Figure 4. After manual mini-implant insertion: the third row (R) served as sites for the reference implants (Dual Top™ 1.6 × 8 mm).

The measuring system's software was programmed so that the robot arm rotated 80o within 2 seconds. During rotation, insertion torques were measured and recorded as a function of the rotation angle. Maximum torque values detected during the measurements underwent further data analysis. All maximum insertion torques were transferred to a pivot table (Excel® 2003, Microsoft®) as absolute measurements (Mabs) and categorized depending on the implant type. To establish comparability between the measurements from the different bone segments, the measured insertion torque Mabs was standardized as relative insertion torque Mrel using the respective insertion torque of the reference implant MR of the same column in the insertion raster [31]. As such, Mrel represents the insertion torque into a bone having an average compacta thickness: Mrel = MR Mabs × 100 The graphic representation in the form of box plot diagrams, as well as the statistical tests were carried out with the statistics software SPSS® 12.0 (SPSS Inc., Chicago, IL, USA). The average values of the individual measurements were tested for significance using the Mann-Whitney U and the Kruskal-Wallis test for non-parametric samples. Maximum error was limited to $p < 0.05$.

RESULTS

The measured insertion torques and hence primary stability revealed strong differences depending on the mini-implant's diameter and design. Maximum insertion torques was observed between 10 and 480 Nmm (1–48 Ncm). The mini-implant's diameter had a particularly great impact. Comparing conical and cylindrical mini-implant types from the same manufacturer, yielded the following measurement results: the conical AbsoAnchor® SH 1413-08 showed significantly higher insertion torques (primary stabilities) than the cylindrical AbsoAnchor® SH 14-08. The conical Spider Screw® K1 1.5 × 8 mm demonstrated significantly higher insertion torques (primary stabilities) than the Spider Screw® 1.5 × 8 mm with the cylindrical thread design as well.

DISCUSSION

It is obvious from our results that both the thread design and diameter of mini-implants have a great impact on their primary stability. The intraosseous part's conical design seems to be superior to the cylindrical design. The ORLUS mini-implant showed the greatest insertion torques even though its diameter is only 1.8 mm. We assume that the large inner diameter of the thread part in the area around the implant neck is responsible for this. Sufficient primary stability is essential to minimize the risk of implant loss and as such, to establish successful anchorage. According to Motoyoshi et al. [24], the insertion torque should be at least 50 Nmm. It became obvious in this study that especially the mini-implants of small diameter fail to achieve this 50-Nmm minimum. This observation is supported by clinical studies demonstrating higher loss rates of mini-implants smaller in diameter [3, 6, 29]. Although the required insertion torque can be increased by a conical thread design in comparison with the cylindrical form, the AbsoAnchor® SH 1413-08 usually only achieves values below 50 Nmm even with the conical design. Thus from today's perspective, it seems advisable to choose a mini-implant of adequate dimensions. Nevertheless, we must each time take the available space and anatomical insertion possibilities into consideration as well. With the objective of achieving high insertion torques and hence sufficient primary stability on the one hand, and of preventing implant fractures on the other, it is obligatory that the appropriate implant be selected according to the insertion region and expected bone quality. The problem as to whether very high insertion torques (besides risking implant fracture) also increase the risk of implant loss due to unnecessary bone compression has not been well explored yet, and should be the objective of further clinical studies. We think that the advanced loss rates in the lower jaw are due to this factor [3, 24]. There are issues other than primary stability to deliberate, such as the magnitude of applied forces and torques, the softtissue situation, oral hygiene, smoking habits, and patient age, all of which may exert a pertinent influence on the stability and survival rate of an implant.

CONCLUSION

This in-vitro study suggests the abundant impact that the diameter and design of mini-implants have on primary stability. The conical thread design attained superior primary stabilities to the cylindrical design

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