Comparative study of fracture torque for orthodontic mini-implants of different trademarks

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Abstract

Objective: To assess the maximum fracture torque of orthodontic mini-implants of different trade marks.

Materials and methods: Seventy-five orthodontic mini-implants were divided into five groups (n = 15) according to their respective manufacturers, namely, groups M, N, S, I and T. The mini-implants were inserted into the swine femoral cortical bone with approximately 8 mm in thickness and a digital torque gauge was perpendicularly positioned to the bone surface. The values obtained from the experiment were submitted to analysis of variance and Tukey’s test.

Results: Group S had the highest values for fracture torque (mean = 99.15 N/cm²), whereas Group N had the lowest ones (mean = 49.6 N/cm²). No statistically significant differences were found between groups M and N (P = 0.904), M and T (P = 0.810), and I and T (P = 0.990).

Conclusions: The mini-implants of Group S were found to be the most resistant to fracture compared with other groups. The resistance to fracture is directly related to the mini-implant format, which helps distributing the force between the head and active part of the mini-implant.

Key words: anchorage, orthodontic mini-implant, torque

Clinical relevance

Similarly to the conventional dental implant systems, those practitioners inserting mini-implants should take special care either during the surgery itself or during the phase of orthodontic force application, as deformation or even fracture of such mini-implants is more likely to occur when inserting or removing them.

Introduction

Anchorage control is a crucial aspect in the orthodontic biomechanics, as loosing it during the treatment can increase the length of treatment and lead to unfavourable outcomes. Extra-oral appliances have been used for years for such a purpose as they provide the results expected by orthodontists. On the other hand, because of aesthetic reasons, patients have increasingly had aversion to extra-oral appliances.

As a result, orthodontic mini-implants were developed in order to provide several advantages such as skeletal anchorage for non-cooperative patients, aesthetics, easy insertion and removal, and relatively low costs.

Despite the great popularity achieved by the mini-implants, there are few studies assessing their mechanical characteristics. Several case studies have been published since the emergence of orthodontic mini-implants, but their mechanical features are rarely assessed. In our opinion, it seems rational to assess the mechanical characteristics of these orthodontic products because of their reduced diameter, which may lead to a decreased mechanical resistance and consequently reduced maximum torque for permanent deformation and fracture. Because the
incidence of mini-implant fracture reported in literature is about 4%\textsuperscript{11,12}.

Based on this supposition, the objective of the present study was to assess the maximum fracture torque in orthodontic mini-implants of different trade marks.

**Methods and materials**

A total of 75 orthodontic mini-implants made of Ti6Al4V alloy and produced by different manufacturers (Fig. 1) were divided into five groups as described in Table 1.

Prior to the fracture mechanical test, the orthodontic mini-implants were analysed by using a JEOL scanning microscope (2000 FX, Tokyo, Japan) with 15X magnification in order to correlate their shapes with the values obtained in the mechanical essay.

Once the mini-implants were selected for mechanical test, they were inserted into 8 mm thick cortical bone obtained from a swine (*Sus scrofa Piau*), femur.

A digital torque gauge (TQ-680, Instrutherm, São Paulo, Brazil) was perpendicularly positioned to the bone surface by using a device specially prepared for such a purpose, thus allowing the mini-implants to be correctly inserted and the fracture torque to be measured. Also, this device allowed the digital torque gauge to approximate as the mini-implant was inserted into the bone cortical in addition to avoid lateral movements, which might result in bascular fracture (Fig. 2).

Statistical analyses were performed by means of SPSS v.13.0 software (SPSS inc., Chicago, IL, USA). Statistical descriptive analysis, including mean, standard deviation, median, min and max values, was calculated for the five groups. The values for maximum fracture torque were obtained in N/cm\textsuperscript{2} and then submitted to variance analysis (ANOVA) in order to determine possible statistical differences between the groups. Next, Tukey’s test was performed as well.

**Results**

With regard to torsional strength, no statistically significant differences were found between groups M and N (*P* = 0.904), M and T (*P* = 0.810), I and T (*P* = 0.990). On the other hand, statistical differences were found between groups M and S (*P* = 0.000), M and I (*P* = 0.026), N and S (*P* = 0.000), N and I (*P* = 0.002), N and T (*P* = 0.009), S and I (*P* = 0.000), and S and T (*P* = 0.000) as demonstrated in Table 2.

![Figure 1](image1) Microphotograph of mini-implants after mechanical essay (15x magnification).

![Table 1](image2) Distribution of samples according to their diameter, length, and alloy

<table>
<thead>
<tr>
<th>Groups</th>
<th>Trade marks</th>
<th>n</th>
<th>Diameter</th>
<th>Length</th>
<th>Alloy</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>Mondeal</td>
<td>15</td>
<td>1.5</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>Neodent</td>
<td>15</td>
<td>1.6</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>Sin</td>
<td>15</td>
<td>1.6</td>
<td>6</td>
<td>Ti-6Al-4V</td>
</tr>
<tr>
<td>I</td>
<td>INP</td>
<td>15</td>
<td>1.5</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>Titanium Fix</td>
<td>15</td>
<td>1.5</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

The highest mean value for fracture torque was obtained in group S, whereas the lowest one was obtained in group N, both containing mini-implants with the same diameter as shown in Figure 3.

**Discussion**

One can use the mechanical torque test for assessing the maximum torque strength of a certain material. This method consists in applying a force on the samples or finished products by inducing a rotational movement around their resistance axis.

In order to assess the maximum fracture torque in mini-implants, it was manufactured a device allowing the digital torque gauge to be attached so that both insertion and measurement could be precisely done. This methodology was developed because of the lack of reliable studies and the increasingly demand for mini-implants in recent years.

Cortical femoral bone of swine (*Sus scrofa Piau*), was used for the present study because of its density of 1.7 g/cm³, which is close to that found by Misch et al., who evaluated human mandibles (0.85–1.53 g/cm³). The present study compared five different orthodontic mini-implants regarding their maximum fracture torque. The results showed a direct relationship between maximum torque and diameter of mini-implants in groups M, S, I and T. This finding corroborates those found by Jolley & Chung and Lim, Cha & Hwang.

However, such a relationship between fracture torque strength and diameter was not observed in the mini-implants of group N, as their shape, instead of the diameter itself, had favoured load concentration on the transmucous head part despite fracturing with reduced loads. Head shape also influenced the fracture torque for orthodontic mini-implants.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Minimum</th>
<th>Mean</th>
<th>Maximum</th>
<th>Median</th>
<th>SD</th>
<th>Statistic†</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>44.7</td>
<td>50.52</td>
<td>56</td>
<td>50.75</td>
<td>2.87</td>
<td>AD</td>
</tr>
<tr>
<td>N</td>
<td>47.8</td>
<td>49.6</td>
<td>51</td>
<td>49.8</td>
<td>0.89</td>
<td>A</td>
</tr>
<tr>
<td>S</td>
<td>93.5</td>
<td>99.15</td>
<td>104.5</td>
<td>99.5</td>
<td>3.41</td>
<td>B</td>
</tr>
<tr>
<td>I</td>
<td>51.5</td>
<td>55.18</td>
<td>62.4</td>
<td>54.3</td>
<td>3.35</td>
<td>C</td>
</tr>
<tr>
<td>T</td>
<td>44.5</td>
<td>54.48</td>
<td>63.2</td>
<td>54.85</td>
<td>4.78</td>
<td>DC</td>
</tr>
</tbody>
</table>

†Equal letters = no statistically significant difference (\(P > 0.05\)).

![Figure 2](image1.png) Digital torque gauge mounted onto device during fracture torque essay.

![Figure 3](image2.png) Box plot for values of mechanical torque essay regarding the five groups assessed.

Table 2 Statistical descriptive analysis of the torsional values for all five groups assessed (N/cm²)

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strength of mini-implants of group M, which had 1.5 mm diameter.

Because of their shape, the mini-implants of group S were found to have the highest values compared with other groups. The transmucous area corresponding to the transition area between head and active parts of the mini-implant continues towards the screw part, thus avoiding force accumulation inferior to 90N/cm² because of the better load distribution. The mini-implants of groups I and T showed moderate values compared with groups N and S. These values are directly related to the shape of the former as the interface between head and transmucous area is more delicate than in group N.

Although mini-implants of group N had mean value of 49.6 N/cm², it was found to be enough for insertion. According to Song et al., caution should be taken when cortical bones measuring more than 2 mm are involved, as the optimal torque needed to insert mini-implants of different formats ranges from 20 to 40 N/cm².

When the treatment plan orientates the placement of mini-implants in thick cortical bone regions, it is worth using a pilot drill if mini-implants from Groups M and N are to be used, thus reducing the possibility of fracture.

It should also be emphasised that the maximum torque values obtained in the present work were found to be higher than those described by Motoyoshi et al., i.e. 5–10 N/cm². According to the authors, the excessive torque can result in fracture of the mini-implant and instability at the interface between mini-implant and bone because of necrosis. Whenever possible, therefore, mini-implants should be inserted by using a torque gauge in order to keep the torque values within an acceptable clinical range, thus respecting the patient’s biological structures and the mini-implant’s mechanical characteristics as well.

**Conclusion**

Despite the great variation regarding the maximum fracture torque, the mini-implants of all groups were found to be suitable for clinical use.

The shape of the mini-implant seems to have more influence on the fracture strength than the diameter.

**References**