# *In vitro* evaluation of flexural strength of different brands of expansion screws

Kádna Fernanda Mendes de Oliveira[1], Mário Vedovello Filho[2], Mayury Kuramae[3], Adriana Simoni Lucato[3], Heloisa Cristina Valdhigi[4]

**Objective:** The objective of this study was to compare the flexural strength of the stems of three maxillary expanders screws of Morelli, Forestadent and Dentaurum brands.

**Methods:** The sample consisted of nine expander screws (totalizing of 36 stems), three from each brand, all stainless steel and 12 mm of expansion capacity. The stems of the expander screws were cut with cutting pliers close to the weld region with screw body, then fixed in a universal testing machine Instron 4411 for tests of bending resistance of three points. The ultimate strength in kgF exerted by the machine to bend the stem of the 5 mm screw was recorded and the flexural strength was calculated using a mathematical formula. During the flexural strength test it was verified the modulus of elasticity of the stems by means of Bluehill 2 software. The flexural strength data were subjected to ANOVA with one criterion and Tukey's test, with significance level of 5%.

**Results:** Forestadent screw brand showed the greatest bending strength, significantly higher than Dentaurum. Morelli showed the lowest resistance.

**Conclusion:** The flexural strength of the screws varied according to the brand. Forestadent screw showed the greatest resistance and Morelli the lowest. All the three screws were found adequate for use in procedures for rapid maxillary expansion.

**Keywords:** Palatal expansion technique. Corrective orthodontics. Malocclusion.

[1] MSc in Orthodontics, UNIARARAS.

[2] Coordinator and Professor of Post-Graduation program in Orthodontics, UNIARARAS.

[3] Professor of Post-Graduation program in Orthodontics, UNIARARAS.

[4] Professor of MSc in Orthodontics, UNIARARAS.

**How to cite this article:** Oliveira KFM, Vedovello Filho M, Kuramae M, Lucato AS, Valdhigi HC. In vitro evaluation of flexural strength of different brands of expansion screws. Dental Press J Orthod. 2012 May-June;17(3):103-7.

**Submitted:** May 29, 2009 - **Revised and accepted:** April 26, 2010

» The authors report no commercial, proprietary, or financial interest in the products or companies described in this article.

**Contact address:** Mayury Kuramae
R. Ytaipu, 422 – Apto 303 – Mirandópolis – Zip code: 04.052-010
São Paulo/SP – Brazil – E-mail: mayury@bol.com.br

## INTRODUCTION

Rapid maxillary expansion (RME) has been shown to be an efficient method for correcting skeletal posterior crossbite[6,16]. The success of RME performed in young patients may also be extended to adult patients by means of surgically assisted maxillary expansion.[11] To increase the efficiency of the forces generated by the expansion screw, osteotomies are performed attenuating the stress generated by osseous attachments releasing the median palatine suture.[3,4] This procedure optimize the orthopedic effect preventing the undesirable dental effects represented by the inclination of the teeth.[1,10]

The force released by the expanders produces areas of compression in the periodontal ligament of the supporting teeth, leading to bone resorption and subsequent dental movement. Expander appliances such as Hyrax type, which concentrate the force in the dentoalveolar areas, may be more iatrogenic from the periodontal point of view and may cause more root resorption than the expanders of the Haas type, which distribute the force among the anchorage teeth and the surface of the palate.[15]

There are important differences between facial orthopedic procedures that use rapid expansion or just simple orthodontic procedures. Orthodontic mechanics are used aiming constant forces application for a long period of time, seeking more physiological, skeletal and periodontal responses. Whereas the rapid maxillary expansion produces heavy forces aiming minimum dental movement and maximum orthopedic response. Therefore, it is fundamental that maxillary expansion appliances have sufficient resistance to bear the required forces for facial orthopedic procedures.

The application of orthodontic forces during rapid maxillary expansion, the effects on sutures, teeth and periodontium, as well as types of appliance has been extensively evaluated.[2,7,17,5] However, there is a notable lack of studies related to the resistance of screws used in rapid maxillary expansion. The resistance of expansion appliances has a direct influence on the amount of force transmitted to the teeth and, consequently, to the median palatine suture region. Therefore, the aim of this study was to evaluate the three point flexural bending resistance of the bars of expansion screws used in rapid maxillary expansion procedures.

## MATERIAL AND METHODS

The sample consisted of 3 expansions screws from 3 different manufactures (Morelli, Dentaurum and Forestadent). Each expansion screw is composed of 4 bars, totalizing 12 bars per group (n=12). The characteristics of the screws used are described in Table 1.

### Three point flexural bending test

For the three point flexural bending test, the bars of the maxillary expansion appliances were cut with pliers suitable for cutting thick wires close to the joint between the bar and the screw body.

Bars were then placed in a centralized position on a device with bilateral support, so that the distance between the supports could be set in 20 mm (Fig 1). Next, the device set was placed in the universal test machine Instron 4411, so that the chisel was placed equidistant from the supports (Fig 1A). To perform the test, the machine was programmed to displace 5 mm at a speed of 1 mm/min (Fig 1B). Maximum force (kgF) exerted to bend the screw bar in 5 mm was recorded and the bending resistance calculated by means of the following formula:

$$S = \frac{2.546473 \times F \times D}{T^3},$$

- 2.546473= Constant for calculating the resistance of metal bars
- S = Flexural strength (kgF)
- F = Force (N)
- D = Distance between the supports (mm)
- T = Thickness of the wire (mm)

To evaluate modulus of elasticity, which was obtained from the tension x deformation graph of the materials (Figs 2, 3 and 4) during the flexural bending resistance test, Bluehill 2 (Instron Inc., version 2.17) test monitoring software was used. The modulus of elasticity represents the stiffness of the material to a certain deformation, within the elastic limit. Therefore, the greater is the modulus of elasticity, higher is the stiffness of the evaluated material. After test, data obtained were submitted to the one-way Analysis of Variance and the Tukey Test, with a level of significance of 5%.

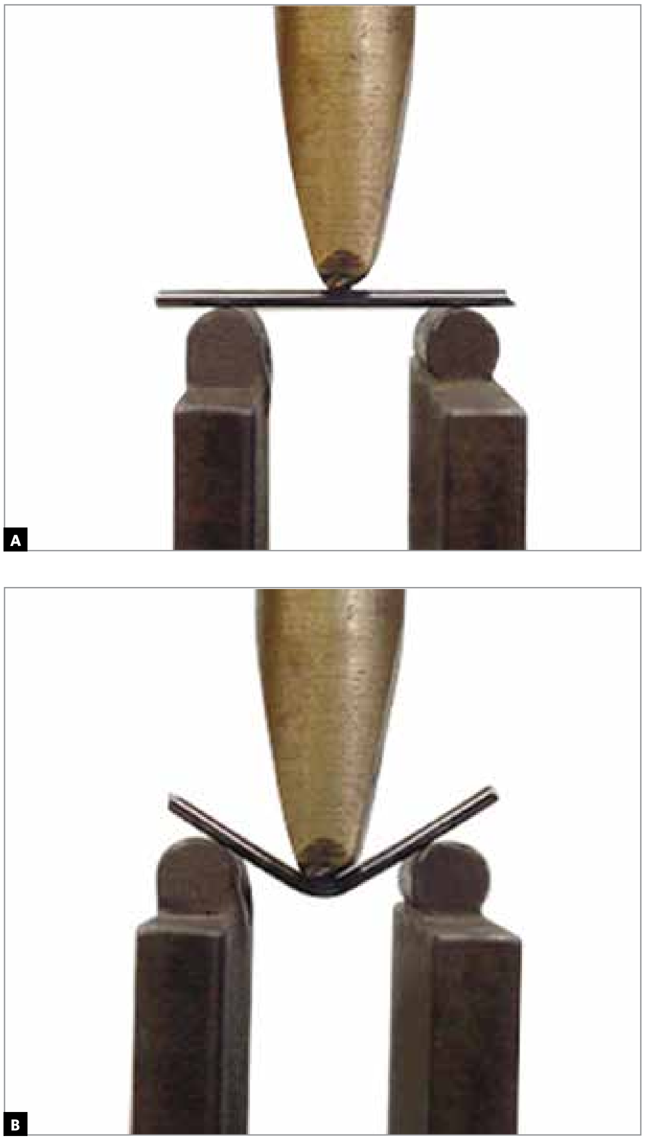

Figure 1 - *In vitro* evaluation of flexural strength of different brands of screw expanders. (**A**) The screw stem positioned before the test, (**B**) after flexural test.

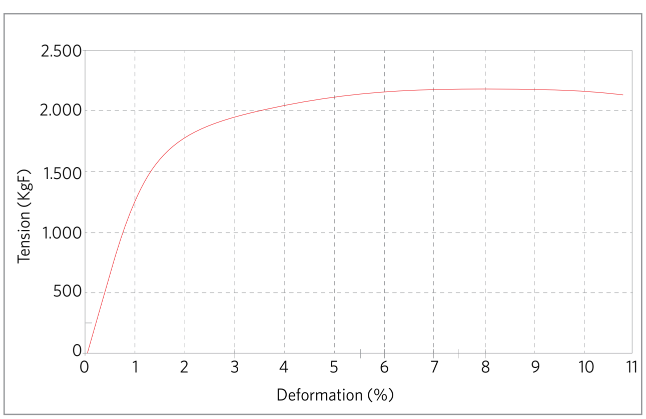


**Figure 2** - Stress x deformation showing the flexural strength of Morelli screw.

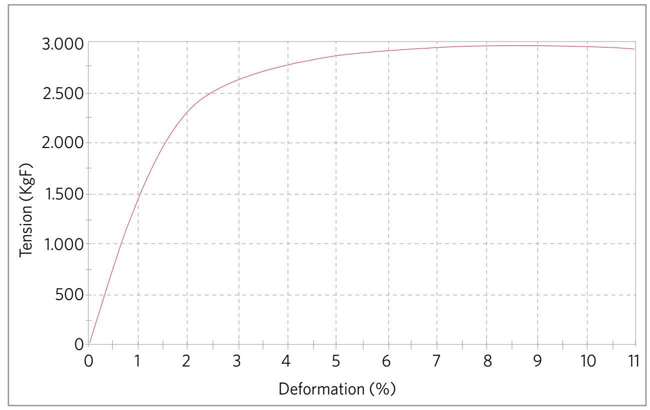


**Figure 3** - Stress x deformation showing the flexural strength of the Forestadent screw.

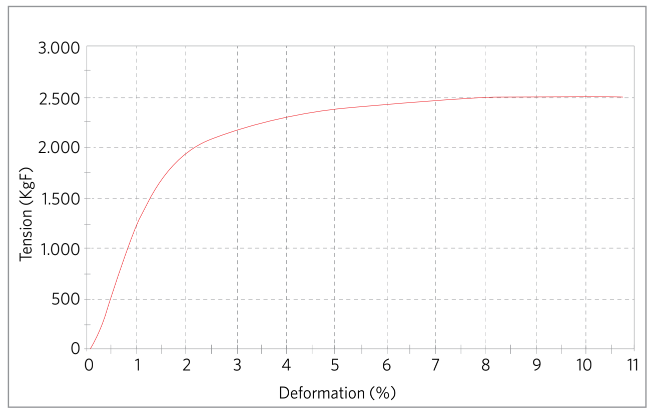


**Figure 4** - Stress x strain showing the flexural strength of the Dentaurum screw.

## RESULTS

The one-way Analysis of Variance showed that there was statistically significant difference among the evaluated screws ($p<0.01$). The results described in Table 2 show that Forestadent screw presented the highest bending resistance, significantly higher than the value of Dentaurum screw, which was significantly higher than the obtained for that of Morelli screw ($p<0.05$). The results of the modulus of elasticity showed that Forestadent screw had the greatest modulus of elasticity (154 GPa), followed by Dentaurum (140 GPa) and Morelli screw (136 GPa), (Table 2).

## DISCUSSION

The mechanical properties are one of the most important characteristics of metals during the various applications. In orthodontic and orthopedic

**Table 1** - Characteristics and brands of expansion screws analyzed.

| Group | Commercial brand | Characteristics |
|---|---|---|
| Group 1 | Morelli, Sorocaba, Brazil | Stainless steel. Expansion capability 12 mm. |
| Group 2 | Dentaurum, Ispringen, Germany | Stainless steel. Expansion capability 12 mm. Stem diameter 1.45 mm. |
| Group 3 | Forestadent, Pforzheim, Germany | Stainless steel. Expansion capability 12 mm. Stem diameter 1.45 mm. |

**Table 2** - Mean (standard deviation) of bending resistance of three points (MPa) and modulus of elasticity (GPa) of expansion screws of three brands evaluated: Morelli, Dentaurum and Forestadent.

| Commercial brands | Bending resistance (MPa) | | Modulus of elasticity (GPa) |
|---|---|---|---|
| Morelli | 2370.38 (33,91) | C | 136 |
| Dentaurum | 2517.75 (33,14) | B | 140 |
| Forestadent | 3477.72 (79,48) | A | 154 |

Different letters represent statistically significant difference ($p<0.05\%$).

treatments, such as rapid maxillary expansion, the metal wires and expander screw are submitted to mechanical load that cause localized residual tensions, capable of causing permanent deformations. The material must have sufficient resistance to the stresses involved in the movements of the articulations and biocompatibility, without releasing toxic products into the oral environment.[9,8] Characterization of the metal alloy and the expansion screw behavior is very important in order to know the real conditions, possibilities and limitations of use because screws are offered on the market by various manufacturers, frequently without adequate specification of properties.

Statistical analysis of data obtained in the mechanical flexural bending resistance tests showed that Forestadent screw showed a significantly higher bending resistance than Dentaurum screws. Subsequently, Dentaurum screws presented a significantly higher value than the Morelli ones (Table 1). During activations, forces are generated with magnitudes ranging from 1000 to 3500 grams in a single activation and accumulate over 7000 grams during the consecutive activations.[19] These results indicate the possibility of using Forestadent screws in clinical situations that may require greater expansion screw rigidity, such as rapid maxillary expansion performed in adult patients. The higher resistance values may be explained by the greater modulus of elasticity presented by this screw, making this material more resistant to deformation, leading to better force transmission to the sutures during screw activations in comparison with other screws. Moreover, the screws of the three tested brands can be used in all cases of rapid maxillary expansion. However, when greater resistance of the screw bars is required, the choice must be the most resistant one, that according to the present study is Forestadent followed by the Dentaurum and Morelli screws.

Rapid maxillary expansion provides heavy forces, above 450 N,[13,14,19] which can easily open the median palatine suture in young patients.[12,18] Therefore, the results of the flexural bending tests suggest that the expansion screws present suitable resistance for satisfactory rapid maxillary expansion procedure, without harm to the expansion screw and, obviously, not compromising the RME procedure.

## CONCLUSIONS

The flexural bending resistance of the screws was influenced by the commercial brand. Among the manufacturers tested, Forestadent screw presented the highest bending resistance and modulus of elasticity, followed by Dentaurum and Morelli screws. The three screws presented adequate flexural bending resistance for use in rapid maxillary expansion procedures.

**REFERENCES**

1. Adkins MD, Nanda RS, Currier GF. Arch perimeter changes on rapid palatal expansion. Am J Orthod Dentofacial Orthop. 1990 Mar;97(3):194-9.
2. Andreasen GF. Variable continuous forces. Aust Dent J. 1970 Feb;15(1):10-5.
3. Bell WH, Jacobs JD. Surgical-orthodontic correction of horizontal maxillary deficiency. J Oral Surg. 1979 Dec;37(12):897-902.
4. Betts NJ, Vanarsdall RL, Barber HD, Higgins-Barber K, Fonseca RJ. Diagnosis and treatment of transverse maxillary deficiency. Int J Adult Orthodon Orthognath Surg. 1995;10(2):75-96.
5. Braun S, Bottrel JA, Lee KG, Lunazzi JJ, Legan HL. The biomechanics of rapid maxillary sutural expansion. Am J Orthod Dentofacial Orthop. 2000 Sep;118(3):257-61.
6. Capelozza Filho L, Silva Filho OG. Expansão rápida da maxila: considerações gerais e aplicações clínicas. In: Interlandi S. Ortodontia. 3a ed. São Paulo (SP): Artes Médicas; 1994. p. 393-418.
7. Chaconas SJ, Caputo AA. Observation of orthopedic force distribution produced by maxillary orthodontic appliances. Am J Orthod. 1982 Dec;82(6):492-501.
8. Cotrim-Ferreira FA. Biomecânica do movimento dental. In: Vellini-Ferreira F. Ortodontia: diagnóstico e planejamento clínico. São Paulo (SP): Artes Médicas; 1996. p. 353-90.
9. Drake SR, Wayne DM, Powers JM, Asgar K. Mechanical properties of orthodontic wires in tension, bending, and torsion. Am J Orthod. 1982 Sep;82(3):206-10.
10. Garib DG, Henriques JF, Janson G, Freitas MR, Coelho RA. Rapid maxillary expansion—tooth tissue-borne versus tooth-borne expanders: a computed tomography evaluation of dentoskeletal effects. Angle Orthod. 2005 Jul;75(4):548-57.
11. Gurgel JA, Sant'Ana E, Henriques JFC. Tratamento ortodôntico-cirúrgico das deficiências transversais da maxila. R Dental Press Ortodon Ortop Facial. 2001 nov-dez;6(6):59-66.
12. Haas AJ. The treatment of maxillary deficiency by opening the midpalatal suture. Angle Orthod. 1965 Jul;35:200-17.
13. Isaacson RJW, Wood JL, Ingram AH. Forces produced by rapid maxillary expansion I. Design of the force measuring system. Angle Orthod. 1964;34(4):256-60.
14. Isaacson RJW, Wood JL, Ingram AH. Forces produced by rapid maxillary expansion II. Forces present during treatment. Angle Orthod. 1964;34(4):261-70.
15. Odenrick L, Karlander EL, Pierce A, Kretschmar U. Surface resorption following two forms of rapid maxillary expansion. Eur J Orthod. 1991 Aug;13(4):264-70.
16. Silva Filho OG, Capelloza Filho, L, Fornazari, RF, Cavassan, AO. Expansão rápida da maxila: um ensaio sobre a sua instabilidade. R Dental Press Ortodon Ortop Facial. 2003 Jan-Fev;8(1):17-36.
17. Southard KA, Forbes DP. The effects of force magnitude on a sutural model: a quantitative approach. Am J Orthod Dentofacial Orthop. 1988 Jun;93(6):460-6.
18. Timms DJ. A study of basal movement with rapid maxillary expansion. Am J Orthod. 1980 May;77(5):500-7.
19. Zimring JF, Isaacson RJ. Forces produced by rapid maxillary expansion. 3. Forces present during retention. Angle Orthod. 1965 Jul;35:178-86.