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# CBCT Assessment of Dental and Skeletal Arch Changes Using The Damon Vs Conventional (MBT) System

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## Abstract

**Introduction:** The primary purpose of this study was to evaluate changes in dental and skeletal arch width and length. The secondary purpose was to evaluate differences between the three CBCT views (3D coordinate, sectional, andvolume views).

**Methods:** Eleven Patients (≥18 years of age) with moderate to severe crowding who had both pre- and post-treatment CBCTs and were treated with non-extraction, either with conventional edgewise appliances or with a self-ligating Damon system were retrospectively selected from two orthodontic practices. The arch length, inter-occlusal, inter-apical, inter-buccal and inter-lingual alveolar crest arch widths, and the buccolingual angulation for canine, premolars and first molars were measured. Different CBCT views were evaluated by first measuring the interocclusal distances of the respective teeth in the coronal section and the volume views. These measurements were compared with those gathered previously using the 3D coordinate system. A paired *t*-test, an independent *t*-test, and an ANOVA were used for statistical analysis.

**Results:** Both non-extraction treatment modalities resulted in interocclusal arch width expansion in both the maxilla and the mandible. The overall expansion of arches in the Damon treated cases, was statistically greater than in the conventionally treated cases. Maxillary and mandibular arch lengths were increased but not significantly in both groups. There were no statistically significant differences between the three different CBCT views.

**Conclusion:** Both the Damon and conventional systems resulted in increased arch width and length, but the Damon system caused significantly more overall arch expansion.

**Keywords:** CBCT, ANOVA, 3-D View.

## Introduction

Anecdotal statements and case reports have been made regarding the Damon System's ability to achieve biologically induced tooth movements and treatment that in most cases does not require the extraction of permanent teeth, rapid palatal expansion, or distalization of molars. This technique purports that teeth are moved to physiologically determined positions with minimal tipping in all planes of space and the alveolar bone will follow. In this age of evidence-based treatment, it is imperative that the results claimed are placed under the scrutiny of peer review that either prove or refute these statements.

The so-called "swinging pendulum" of extraction versus non-extraction treatment that began with the great Dewey – Case Debates of 1911(Asbell, 1990) remains unresolved to this day. E. H. Angle initially provided extraction treatment for his patients, but modified his approach to therapy based upon the philosophy that a full complement of teeth can be maintained by modifying the environment surrounding the dentition (Lee, 1999). Opposed to this non-extraction form of therapy were Tweed and Begg, who became dissatisfied when patients examined during the retention period demonstrated relapse due to the lateral expansion and proclination of the dental arches (Brandt and Tweed, 1967). It should be emphasized that the forces used to provide non-extraction therapy during the time of Angle were higher than those used today, and according to Ward, Workman, Brown, and Richmond (2006) very little work has been done with the type of appliance and protocol currently in use.

Computer Tomography (CT) and CBCT allows us to utilize 3D images which are increasingly used for planning and evaluating various dental procedures. For conventional CT images, a thin collimated fan of radiation is projected through the subject and is recorded on a thin linear sensor as the x-ray machine circles the subject. The patient is then advanced in the scanner and data are recorded for a new slice. The information on each slice is stacked up above one another creating a 3D image. Modern scanners employ a helical geometry so that a patient passes continuously through the imaging apparatus and avoids discrete stops between slices.

The primary purposes of this research were to evaluate the changes in arch dimensions of non-extraction treated cases using CBCT.

1. Damon initial vs. Damon final- To evaluate the changes in dental and skeletal arch width and length in patientstreated with the Damon System.
2. Conventional initial vs. Conventional final- To evaluate the changes in dental and skeletal arch width and length in patients treated with the Conventional mechanics.
3. Damon vs. Conventional-To evaluate the changes in the dental and skeletal arch widths and arch length measurements of patients that were treated with the Damon System compared to patients treated with the Conventional mechanics.

## Materials And Methods

Patients were retrospectively selected from two private orthodontic practices. The patients received treatment utilizing a Conventional edgewise appliance (MBT), or in ulitizing a self-ligating Damon system. Both systems used 0.022-in archwire slots. Patients with moderate (3-6) mm to severe (>6 mm) crowding as was judged by clinicians were utilized. Eleven subjects were selected in this study based on the following:

Patients having a chronological age of 18 years or older, class I occlusion or mild class II/III malocclusion, moderate to severe crowding (as judged by the treating clinician), non-extraction treatment, no interproximal reduction, no therapeutic intervention exclusive of archwires, o surgical intervention, available initial and final CBCT and no missing teeth, excluding second and third molars were included in the study. At the same time patients prior to pubertal growth, extraction at any point during treatment, missing teeth, excluding second and third molars, pathology associated with head and neck area and radiation to head and neck area were excluded. Five patients who received treatment of both the maxillary and mandibular arches in both treatment categories, and one patient in the Damon group with only mandibular arch fitting the criteria were included in the study. In the group treated with the Conventional edgewise system, the brackets used were Unitek APC with MBT prescription (0.022" slot). The treating orthodontist typically used the following archwire sequence which were ligated mainly with elastomeric ligation:

**Maxilla/Mandible**

- 0.014- to 0.016-inch NiTi
- 0.018 -inch SS
- 0.016±0.022-inch NiTi
- 0.018±0.025-inch SS or 0.019±0.025-inch SS

In the group treated with the Damon appliance, self-ligating brackets (Ormco) were utilized. The following Ormco archwires were sequentially use:

| **Maxilla:** | Mandible |
|---|---|
| • 0.014- to 0.016-inch CuNiTi<br>• 0.016±0.025-inch CuNiTi<br>• 0.018±0.025-inch CuNiTi<br>• 0.019±0.025-inch SS | • 0.014- to 0.016-inch CuNiTi<br>• 0.014±0.025-inch CuNiTi<br>• 0.018±0.025-inch CuNiTi<br>• 0.016±0.025-inch SS |

Since, all CBCTs were obtained with patients in centric occlusion, the non-functional cusps in each arch were used to measure the inter-occlusal arch widths for better cusp tip views. The arch width was measured at the first molar, first and second premolars, and the cuspids in both arches. The arch width measurements included not only the occlusal portion of the teeth, but also their respective buccal and lingual cortical plates. The inter-apical areas of each of the respective teeth were also measured, along with the angulations of each tooth. Arch length was measured as the distance between the mid- point of the line connecting the mesial of the first molars to the contact point between the central incisors. Arch width, arch length, and tooth angulation were measured at pre- treatment ($T_1$) and post-treatment ($T_2$).

To evaluate changes within each treatment category (Damon or conventional: hypothesis 1 and 2), a paired *t*-test was used.

To evaluate dental and skeletal changes between different treatment groups (hypothesis 3), an independent *t*-test was performed on the differences between initial and final measurements in each treatment category.

## Results

Table 1: Damon and Conventional maxillary arch measurements before and after treatment: inter-occlusal arch dimension (IOD), first molar inter-central fossa (ICF), inter-apical dimension (IAD), and arch length (AL).

| Damon and Conventional – Maxilla Final-Initial | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Damon tx. | | | | | | Conventional tx. | | | | |
| | Tooth | N | Initial mean±SD | Final mean±SD | $t$ | p | | N | Initial mean±SD | Final mean±SD | $t$ | p |
| IOD | K9 | 5 | 34.6±0.7 | 37.1±2.1 | 3.530 | .024* | | 5 | 34.7±4.3 | 35.3±3.2 | 0.548 | .613 |
| | PM1 | 5 | 41.3±2.4 | 44.8±2.5 | 3.688 | .021 | | 5 | 41.0±3.5 | 43.1±2.96 | 3.908 | .017 |
| | PM2 | 5 | 47.0±2.8 | 49.3±3.0 | 3.236 | .032 | | 5 | 46.8±3.6 | 48.0±3.1 | 1.144 | .316 |
| | M1 | 5 | 53.6±3.0 | 54.2±3.2 | 1.404 | .233 | | 5 | 54.9±3.3 | 55.1±2.4 | 0.403 | .708 |
| ICF | M1 | 5 | 46.2±2.5 | 47.4±3.2 | 3.466 | .026 | | 5 | 47.8±3.0 | 47.9±3.5 | 0.204 | .849 |
| IAD | K9 | 5 | 29.0±2.4 | 28.5±2.7 | 0.695 | .525 | | 5 | 29.4±3.8 | 29.96±3.3 | 0.543 | .616 |
| | PM1 | 5 | 36.9±2.8 | 36.1±1.7 | 0.911 | .414 | | 5 | 33.6±4.4 | 36.9±3.3 | 2.597 | .060* |
| | PM2 | 5 | 36.9±2.2 | 36.2±2.8 | 1.389 | .237 | | 5 | 39.2±2.9 | 40.3±3.5 | 1.705 | .163 |
| | M1 | 5 | 30.5±2.9 | 28.5±3.9 | 1.097 | .334 | | 5 | 35.8±8.7 | 34.3±5.3 | 0.871 | .433 |
| Arch Length | | 5 | 30.7±0.8 | 32.4±1.8 | 2.356 | .078 | | 5 | 31.8±4.7 | 33.1±5.2 | 1.212 | .292 |

*Red = significant, Blue = approaching significance

Table 2: Damon and Conventional mandibular arch measurements before and after treatment: inter-occlusal arch dimension (IOD), first molar inter-central fossa (ICF), inter-apical dimension (IAD), and arch length (AL).

| Damon and Conventional- Mandible Final-Initial | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Damon tx. | | | | | | Conventional tx. | | | | |
| | Tooth | N | Initial mean±SD | Final mean±SD | $t$ | p | | N | Initial mean±SD | Final mean±SD | $t$ | p |
| IOD | K9 | 6 | 22.5±3.7 | 27.6±5.8 | 2.752 | .040* | | 5 | 25.3±3.3 | 28.3±3.5 | 2.881 | .045 |
| | PM1 | 6 | 24.9±2.7 | 30.2±2.5 | 5.061 | .004 | | 5 | 26.6±6.3 | 27.2±3.3 | 0.299 | .780 |
| | PM2 | 6 | 29.2±3.5 | 32.9±2.2 | 4.006 | .010 | | 5 | 31.0±3.6 | 32.5±2.7 | 3.251 | .031 |
| | M1 | 6 | 33.5±3.1 | 36.1±3.2 | 4.671 | .005 | | 5 | 34.8±3.7 | 35.5±3.5 | 2.390 | .075* |
| ICF | M1 | 6 | 41.7±3.4 | 44.5±3.4 | 6.031 | .002 | | 5 | 42.8±3.5 | 43.3±3.8 | 1.301 | .269 |
| IAD | K9 | 6 | 24.5±3.3 | 24.9±2.5 | 0.564 | .597 | | 5 | 22.0±1.1 | 24.3±0.9 | 3.438 | .026 |
| | PM1 | 6 | 33.4±3.1 | 32.2±2.5 | 1.537 | .185 | | 5 | 32.9±4.1 | 32.4±3.2 | 0.769 | .485 |
| | PM2 | 6 | 40.5±2.2 | 41.4±3.2 | 1.519 | .189 | | 5 | 41.9±3.8 | 41.7±3.5 | 0.425 | .692 |
| | M1 | 6 | 49.8±4.3 | 48.7±3.4 | 0.836 | .441 | | 5 | 49.0±3.3 | 50.5±4.4 | 1.517 | .204 |
| Arch Length | | 6 | 21.6±1.2 | 22.3±1.8 | 1.755 | .140 | | 5 | 23.7±6.5 | 24.1±2.2 | 0.150 | .888 |

## Discussion

The Damon System was first introduced in the 1990's and incorporates low friction brackets and low force wire technologies (Damon, 1998). The Damon System includes the use of passive self-ligating brackets, along with continuous low force deflection wires that are reported to produce a dentoalveolar response that appears to be different than conventional fixed mechanics (Damon, 2005). The general philosophy underlying this system is to approximate biologically induced tooth moving forces. The system is claimed to provide a reliable and simple means of achieving the best possible facial balance for each patient through the use of light forces to develop a functional adaptation of the basic arch form based upon the philosophy of maintaining the original arch shape for stability. According to Damon, the alteration of the arch form through this system is "physiologically determined" and creates a new equilibrium that allows the arch to reshape itself to accommodate the teeth (Damon, 2005). Consistent with these beliefs, treatment protocols have been designed which attempt to mirror biological and physiological principles of tooth movement. Proponents of the Damon System believe that light archwires, such as copper nickel-titanium (Cu NiTi), do not overpower lip musculature, and hence the orbicularis oris and mentalis muscles produce a "lip-bumper" effect on the maxillary and mandibular incisors. In this system, teeth take the path of least resistance, which in extraction cases means teeth moving to the extraction site; however, in non-extraction cases, this produces posterior expansion with maintenance of incisors anteroposterior position (Damon, 1998). The Conventional orthodontic dictum suggests insertion of the largest possible wire as early as possible. This approach is thought to provide the clinician with three dimensional "control". Unfortunately, this mechanistic approach cannot take advantage of the surrounding tissues (Damon 1998). Damon argues (1998) that just as teeth appear in their pre-treatment positions, as dictated by the interplay of forces between the cheek, tongue and periodontal forces, these same force systems can be the guiding adjuncts for orthodontic purposes. Damon (1998) believes that in conventional systems, bracket slots filled with large size wires (even flexible ones) generate force systems high enough to overpower musculature and disrupt periodontal integrity. As a result, teeth are flared labially. However, with low-force, low-friction system, not only are these tissues thought not to be overpowered, but they would guide teeth into physiologic positions. These positions (hence the arch form) are determined by the balance of forces within the three tissue system: gingiva, PDL and bone (Damon 1998). Damon states that the arch form produced is natural and functional, and not forced by a predetermined, manufactured form, however the following are representative of studies disputing these statements.

Peck (2008) stated that we know almost nothing about Dwight Damon's early study of 7000 photographs of great smiles that resulted in his ideal arch form - a single shape and size to which Damon System wires are formed. In a study of 19 non-extraction treatments utilizing the Damon appliance, Tang et. al. (2008) found a variety of treatment responses ranging from successful (11 subjects) to unsuccessful (8 subjects) treatment. Among their findings were more forward movement of the lower lip, a decrease in the Z-angle (the angle between Frankfort horizontal and a line drawn from soft tissue pogonion to the most procumbent lip), and soft tissue chin strain in the unsuccessful group. They concluded that the Damon appliance should not be used in all cases with severe crowding, and a straight soft tissue profile and upright incisor position are a prerequisite for non-extraction treatment. Tao et. al. (2008) reviewed the records of 24 non-extraction patients with a Class I skeletal pattern and upper arch crowding greater than 5mm treated with the Damon appliance. They found a significant increase in upper arch length and arch width after the correction of crowding. They also found arch perimeter is gained by the increase in both arch length and inter-bicuspid arch width. The effects of leveling and alignment on arch dimensions and mandibular incisor position have been described for the pre-adjusted, edgewise appliance system (Conventional system). Typical changes involve an increase in arch perimeter caused by incisor advancement and transverse expansion. However, with the exception of some isolated case reports describing significant arch development with the Damon appliance, using dramatically enlarged archwires, there is little scientific research into arch dimensional changes with self-ligating systems. The pattern of arch dimensional changes has implications for long-term stability (Burke, 1998). The ideal scenario would involve little incisor proclination and intercanine expansion, with most of the arch perimeter increase generated by expansion across the molars and premolars. N. Pandis et. al. (2010) in a prospective randomized clinical trial investigated the duration of treatment with self-ligating brackets compared with conventional appliances in cases exhibiting mandibular crowding and the accompanying dental effects. Overall, they showed that, Damon 2 brackets are not more efficient than conventional appliances in terms of the time required to resolve severe anterior mandibular crowding. However, moderate crowding was alleviated 2.7 times faster with the Damon 2 brackets, which they attributed to the greater free play of the self-ligating appliances. They also found that both bracket types alleviate crowding by similar mechanisms that involve mandibular incisor proclination and mild expansion of dental arches. Intermolar width increase in the self-ligating group was 1.5 times greater than in the conventional-appliance group (Pandis, 2007). A systematic review of the literature for treatment utilizing self-ligating brackets (Chen et. al., 2010) indicated that the mechanism to resolve anterior crowding appeared to be the same when comparing conventional and self-ligating systems. This systematic review also showed that shortened chair time and slightly less incisor proclination appeared to be the only significant advantages of self-ligating systems over conventional systems as supported by the current evidence.

Ehsani (2010) evaluated dental and skeletal changes following orthodontic treatment with Damon self-ligating (SL) brackets in 20 non-extraction patients using frontal and lateral cephalometric radiographs that were analyzed in a three-dimensional (3D) analysis computer software program. Bolton templates were used as controls.

Ehsani found that Damon treatment did not result in buccal tipping of molar crowns or maxillary base width increase. In her conclusion, tooth alignment with the Damon system appeared to be accomplished through a combination of arch width changes and incisor proclination and/or lingual root torque.

In a study using dental casts and cephalograms comparing rapid palatal expansion and the Damon appliance on non-extraction treatment, Yu et. al. (2008) found that both RPE and the Damon technique were successful in increasing arch width to correct moderate crowding. According to Yu, the Damon appliance protrudes the upper and lower incisors and expands the dental arch by buccal tipping of bicuspids and molars.

The "lip-bumper" effect of the Damon system was not observed in a study by Vajaria et. al. (2011). Using study models and cephalograms that were scanned and measured, they found that crowding was alleviated through transverse expansion and the incisor advancement was seen in both the conventionally treated and Damon treated groups. Almost all the research that has been done with regard to arch expansion or incisor proclination using conventional versus self-ligating systems has been performed using casts or lateral cephalograms. Conventional radiographic imaging, such as panoramic or intraoral radiographs, has limitations - such as magnification, distortion, superimposition, limited perspective, and lack of resolution. Images obtained by Cone Beam Computer Tomography (CBCT) can measure sectional planes in 3-dimentional spaces. One practical application of CBCT (Mah et. al., 2010) is to offer an undistorted view of tooth roots and 3D spatial orientation of bones and teeth. Therefore, this technology can be utilized in the evaluation of the effects of treatment on the crown, root and bone measurements of individual patients.

**Conclusion**

a. Arch length in the maxilla and mandible increased for both the Conventional and Damon groups with changes in the maxilla of the Damon group approaching significance. But, there was no statistically significant difference between the two groups.
b. Both non-extraction treatment modalities resulted in interocclusal arch width expansion in both the maxilla and the mandible.
c. Arch expansion proved to be statistically and clinically significant in almost all measurements of the maxillary and mandibular arches for the Damon treated cases. Arch expansion in the Conventionally treated cases only proved to be statistically significant for the maxillary PM1, and mandibular

K9 and PM2 arch changes, with the mandibular M1 measurements approaching significance.

**References**


1. Ahlqvist JB, Isberg AM. Validity of computed tomography in imaging thin walls of the temporal bone. Dentomaxillofac Radiol 1999;28:13-9.
2. Asbell, MB. A brief history of orthodontics: American orthodontics 1900 to 1910. Am J Orthod Dentofacial Orthop 1990;98:206-213.
3. Ballrick JW, Palomo JM, Ruch E, Amberman BD, Hans MG. Image distortion and spatial resolution of a commercially available cone-beam computed tomography machine. Am J orthod Dentofacial orthop 2008;134:573-82.
4. Baumrind S. The road to Three-Dimensional Imaging in Orthodontics. Sem. Orthod 2011;17:2-12Vol 17.
5. Begg, PR. Light wire technique employing the principles of differential force. Am J Orthod 1961;47: 30-48,
6. Bergersan EO. A cephalometric study of the clinical use of the mandibular labial bumper. Am J Orthod 1972;61:578-602.
7. Berkovitz BKB, Holland GR, Moxham BJ. A Colour Atlas and Textbook of Oral Anatomy. Wolfe Medical Publications, LTD, Holland 3rd printing, 1984:217-223.
8. Bowman SJ, Johnston LE Jr. The esthetic impact of extraction and nonextraction treatments on Caucasian patients. Angle Orthod 2000;70:3-10.
9. Brandt S, Tweed CH. JPO interviews Dr. Charles H. Tweed. J Clin Orthod, 1967;1(12): 142-148.
10. Burke P, Silveira AM, Goldsmith LJ, Yancey JM, Van Stewart A, Scarfe WC. A meta-analysis of mandibular intercanine width in treatment and postretention. Angle Orthod 1998;68(1):53-60.
11. Cetlin NM, Ten Hoeve A. Nonextraction treatment. J Clin Orthod 1983;17:396-413.
12. Chen Lc, Lundgren T, hallström h, Cherel F. Comparison of different methods of assessing alveolar ridge dimensions prior to dental implant placement. J Periodontol2008;79:401-5
13. Chen SS, Greenlee GM, Kim JE, Smith CL, Huang GJ. Systematic review of self-ligating brackets. Am J Orthod Dentofacial Orthop 2010;137:726.e1-726.e18.
14. Chien P, Parks E, Eraso F, Hartsfield J, Roberts W, Ofner S. Comparison of reliability in anatomical landmark identification using two-dimensional digital cephalometrics and three-dimensional cone beam computed tomography in vivo. Dentomaxillofac Radiol 2009;38:262-73.
15. Creed B, Chung How Kau et al, A Comparison of Accuracy of Linear Measurements Obtained from Cone Beam Computerized Tomography Images and Digital Models. Semin Orthod 2011;17:49-56.
16. Cross, JJ. The Tweed Philosophy: The Tweed Years. Sem Orthod 1996 Vol 2, No. 4 231-236.
17. Dahlberg G. Statistical methods for medical and biological student. New York: Interscience Publications; 1940.
18. Damon DH. The Damon Low-Friction Bracket: A Biologically Compatible Straight-Wire System. JCO/November 1998:670-680.
19. Damon DH. The rationale, evolution and clinical application of self-ligating bracket, Clin Orth Res 1, 1998;52-61.
20. Damstra J, Fourie Z, Huddleston Slater J.J.R., and Ren Y. Reliability and the smallest detectable difference of measurements on 3-dimensional cone-

beam computed tomography images. Am J Orthod Dentofacial Orthop 2011;140:e107-e114.

21. Graber, TM, Vanarsdall RL, & Vig KWL: Orthodontics Current Principles & Techniques, 2005; Damon DH. Treatment of the face with biocompatible orthodontics. Elsevier Mosby, St. Louis, pp. 753-831.
22. Hilgers ML, scarfe Wc, scheetz JP, Farman AG. Accuracy of linear temporomandibular joint measurements with cone beam computed tomography and digital cephalometric radiography. Am J Orthod Dentofacial orthop 2005;128:803-11.
23. Işiksal E, Hazar S, Akyalçin S. Smile esthetics: perception and comparison of treated and untreated smiles. Am J Orthod Dentofacial Orthop 2006;129:8-16.
24. Johnson DK, Smith RJ. Smile esthetics after orthodontic treatment with and without extraction of four first premolars. Am J Orthod Dentofacial Orthop 1995;108:162-7.
25. Lee RT. Arch width and form. Am J Orthod. Dentofac. Orthop 1999;115:305-13.
26. Mah JK, Huang JC, Choo HR. Practical applications of Cone-beam computed tomography in orthodontics. JADA 2010;14:7S-13S.
27. Merrifield LL. The profile line as an aid in critically evaluating facial esthetics. Am J Orthod 1966;52:804-22.
28. Moshiri M, scarfe Wc, Hilgers ML,Sscheetz JP, Silveira AM, Farman AG. Accuracy of linear measurements from imaging plate and lateral cephalometric images derived from cone- beam computed tomography. Am J orthod Dentofacial orthop 2007;132:550-60.
29. Pandis N, Polychronopoulou A, Eliades T. Self-ligating vs. conventional brackets in the treatment of mandibular crowding: A prospective clinical trial of treatment duration and dental effects. Am J Orthod Dentofacial Orthop 2007;132:208-15.
30. Pandis N, Polychronopoulou A, Eliades T. Active or passive self-ligating brackets? A randomized controlled trial of comparative efficiency in resolving maxillary anterior crowding in adolescents. Am J Orthod Dentofacial Orthop 2010(Jan);137(1):12.e1-6;discussion 12-3.
31. Peck S. So What's new? Arch expansion again. Angle Orthod 2008;78:#3; 574-575.
32. Proffit, WR, Fields, HW, and Sarver, DM: Contemporary Orthodontics, 2007, Mosby Elsevier, St Louis pp. 407-411.
33. Sandstrom RA, Klapper L, Papaconstantinou S. Expansion of the lower arch concurrent with rapid maxillary expansion. Am J Orthod Dentofac Orthop 1988;94:296-302.
34. Scholz R. The radiology decision. Sem. Orthod 2011;17:15-19.
35. Tao L, et. al. Arch perimeter changes on non-extraction correction of dental crowding with Damon appliance. Shanghai Kou Qiang Xue, 2008 (June);17(3):243-9 (abstract).