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Article

Morphometric evaluation of the slot of aesthetic orthodontic brackets.

Evaluación morfométrica de la ranura de brackets estéticos ortodóncicos.

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Abstract: Introduction: : Dental malocclusion is a public health problem and orthodontics is the specialty in charge of diagnosing and treating it, aesthetic brackets are an alternative, the costs are varied, which makes its precision doubtful. **Objective:** Evaluate the measurement and geometry of the slot of three brands of aesthetic brackets and verify their precision. **Material and Methods:** Twenty-four aesthetic Roth prescription 0.022" slot polycrystalline ceramic brackets were evaluated in three brands: American Orthodontics (United States), Morelli (Brazil) and Class One (China). Eight samples were measured per group in a specialized laboratory certified in measurement and calibration, the measurements of internal and external height were verified, per mesial and distal; and the parallelism of the slot of each bracket. The results were processed with SPSS 22 and tests of variance (ANOVA), Tukey and Student's t were used. **Results:** The measurements of the brackets' grooves do not correspond to the measurements announced by the manufacturers, these are greater, however, American Orthodontics is within the tolerance range ($p<0.01$); the slots in the mesio-distal direction and the lingual vestibule are not parallel in Morelli and Class One. **Conclusion:** The results of this study indicate that the slots of the supports are oversized, their geometry is not precise and varies greatly between brands and prices. The three-dimensional control of the tooth could be compromised.

Keywords: *orthodontics; orthodontics, corrective; orthodontic brackets; ceramics; orthodontic appliances, fixed; calibration.*

Resumen: Introducción: La maloclusión dental es un problema de salud pública y la ortodoncia es la especialidad encargada de diagnosticarla y tratarla, los brackets estéticos son una alternativa, los costos son variados lo que hace dudar su precisión. **Objetivo:** Evaluar la medida y geometría de la ranura de tres marcas de brackets estéticos y corroborar su precisión. **Material y Métodos:** Se evaluaron 24 brackets estéticos cerámicos policristalinos de ranura 0,022" prescripción Roth en tres marcas: American Orthodontics (Estados Unidos), Morelli (Brasil) y Class One (China). Se midieron ocho muestras por grupo en un laboratorio especializado y certificado en medición y calibración, se verificaron las medidas de altura interna y

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externa, por mesial y distal; y el paralelismo de la ranura de cada brackets. Los resultados fueron procesados con SPSS 22 y se utilizaron pruebas de varianza (ANOVA), Tukey y t de Student. **Resultados:** Las medidas de las ranuras de los brackets no se corresponden con la medida anunciada por los fabricantes, estas son mayores, sin embargo, American Orthodontics y Morelli se encuentra dentro del rango de tolerancia (p<0,01); las ranuras en sentido mesio distal y vestíbulo lingual no son paralelas estadísticamente en Morelli y Class One. **Conclusión:** Los resultados de este estudio indican que las ranuras de los soportes se encuentran sobredimensionadas, su geometría no es precisa y varía mucho entre marcas y precios. El control tridimensional del diente se podría ver comprometido.

Palabra Clave: *ortodoncia; ortodoncia correctiva; soportes ortodóncicos; cerámica; aparatos ortodóncicos fijos; calibración.*

INTRODUCTION.

Malocclusion is a public health concern that severely affects quality of life. The World Health Organization (WHO) reports that it ranks third in prevalence among oral health problems.[1] This pathology not only affects oral physiology and aesthetics, but also negatively impacts psychosocial aspects, damaging people's quality of life.[2,3]

Malocclusion is not only about aesthetics; badly positioned teeth retain food debris that may eventually cause caries and gum disease.[4] It may also decrease the quality of food intake affecting the patient's general health. Additionally, malocclusion can lead to disorders in the temporomandibular joint,[5] occlusal trauma,[6] and be related to body posture problems.[7,8] In serious cases patients may even develop severe disabilities.

Orthodontics is the dental specialty responsible for preventing, diagnosing, and treating malocclusions using fixed and removable appliances.

A fundamental part of fixed orthodontics has to do with the quality and precision of the materials used, the technique, and the expertise of the professional. Among these, materials play an important role in orthodontic biomechanics. The bracket slot is its central component, as it will receive the orthodontic arch and must resist the mechanical force of the basic dental movements, according to the objectives and the treatment plan.[9]

From an orthodontic point of view, the sliding mechanics in the arch-bracket system depend on the wire, the ligation technique, and above all on the material and design of the bracket slot.[10] The effect of the bracket geometry is due essentially to the design of the slot, since the contact area between both surfaces depends on it.[11,12]

In orthodontics, precision is of utmost importance to effectively achieve the planned treatment goals. This is particularly important because the internal and external alveolar bone tables are very thin, and dehiscence and fenestrations are common findings in the lower front and upper back alveolar areas, respectively.[13–15] An inadequate morphology of the slot could alter the position of the teeth due to a change in the information expressed, putting the periodontal health at risk. Therefore, determining the best types of brackets available is of the greatest importance to achieve these objectives.

The introduction in the market of various polycrystalline aesthetic brackets at different prices ranging from 30 to 250 US dollars makes it necessary to determine if their cost has an impact on one of the key aspects related to precision: the measurements of the slot.

The aim of this research is to evaluate the dimension and parallelism of the upper and lower edges of the slot in the mesiodistal and lingual-vestibular direction to assess its geometry and precision. Since medical supplies require strict quality controls, it is likely that the more expensive brackets may offer better geometry and precision.

MATERIALS AND METHODS.

An observational, prospective, cross-sectional study was carried out in the calibration laboratory "Lo Justo S.A.C." ISO/IEC 17025.[16] Twenty-four

new, polycrystalline, ceramic, conventional aesthetic brackets, Roth prescription, 0.022" slot that belonged to the same manufacturing batch of each brand were randomly analyzed. Three brands of brackets were considered: American Orthodontics (20/40TM) manufactured in the United States, Morelli (REF 10.11.900) manufactured in Brazil, and Class One (Acclaim Roth) manufactured in China. These brands are representative of their place of origin, marketed on different continents, and with a significant price difference between them.

The brackets were selected and grouped into a sealed envelope to which a nomenclature, only known to the researcher, was assigned. The nomenclature was A for American Orthodontics, B for Morelli, and C for Class One, to prevent the specialized laboratory staff from identifying each brand. In addition, to avoid positioning errors at the time of evaluation, the distal base of each bracket was marked with an indelible marker before being sent for analysis. The optical comparator Nikon Profile Projector V-16E, Japan, was used for the measurements (Figure 1). An ETI thermohygrometer (calibration certificate TE-056-2016) was used to keep the environment standardized.

The following parameters were considered for the evaluation: the internal dimension (deepest area of the slot), external dimension (outermost area of the slot) of the mesial side (surface closest to the midline of the face), and of the distal side (surface that moves away from the midline of the face) of the bracket slot that corresponds to teeth 1.1, 1.2, 1.3, 1.4, 4.2, 4.3, 4.4, and 4.5, since, according to the Roth prescription, this information is tailored. The reference value used was the vertical measurement of the slot: 0.022 "(0.5588mm) with a tolerance range of 5% +/- 0.0011" (0.0279mm).[17]

The four measurements corresponding to the (a) internal and (b) external height of the bracket were made on the side of the mesial slot and on the distal side (Figure 2A and Figure 2B). The mean of the measurements obtained was compared with the measurement indicated by the bracket manufacturer (0.022") to assess its accuracy. To evaluate the parallelism in the palatal-lingual-vestibulardirection, the measurement between the upper and lower wall of the slot measured in its deepest part (a) and in its most external part (b) was compared (Figure 2). To evaluate the parallelism in the mesiodistal direction, the mean of the measurements obtained between a and b of mesial (c) was compared with the average of a and b of distal (d). (Figure 2B)

For data processing, the following terms were considered: in the palatal-lingual-vestibular direction, *"parallel"* when the height of the slot was the same both internally and externally, *"divergent"* when the internal height was less than the external height, and *"convergent"* when the internal height was greater than the external height. In the mesiodistal direction: *"parallel"* when the height of the slot was the same both mesially and distally, *"divergent"* when the mesial height was less than the distal height, and *"convergent"* when the mesial height was greater than the distal height. (Table 1)

A laboratory record sheet was used for registration. The statistical analysis was descriptive, mean, multiple-range comparison, 95% confidence interval, multiple-range test for the measurement (internal height and external height) of the bracket slot by marks on the piece, Tukey's test and Student's t-test at 95.0% confidence level were used to evaluate parallelism of each brand.

The results were tabulated according to the objectives and variables studied. For data analysis, an Excel 2016 spreadsheet with its analytical complement and the SPSSv.22.0 package was used. Research ethics was respected in all the processes.[18]

Figure 3 shows the procedure diagram of the methodological process.

RESULTS.

Tukey's multiple range test (Table 2) was used to compare the slot measurement between the three brands (Figure 5). It was observed that none of them complies with the exact measurement (0.022"). American Orthodontics with a mean value of 0.0230" +/-0.0010", and Morelli with a value of 0.0245" +/- 0.0011" are within the tolerance range of 5%17 (+/- 0.0011") offered by the manufacturers and considered appropriate. Class One was the one that presented the highest mean value: 0.0253" +/- 0.0015".

When evaluating the mean values of the internal and external vertical dimension of the slot and

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determining its parallelism between the upper and lower walls of the three marks in the palatal-lingual-vestibular direction (Table 3), it is observed that American Orthodontics brackets are statistically parallel according to the Student's t results, t=0.52 p>0.05. There is no significant difference between the internal and external measurements.

On the other hand, the differences according to Student's t in the Morelli and Class One brands are highly significant with t=4.0 p<0.01 and t=2.66 p<0.01, respectively, which indicates that their measurements are divergent. When evaluating the mean values of the dimensions of the slot and parallelism in the mesiodistal direction (Table 4) it is observed that: in the American Orthodontics brackets, there is no statistically significant difference with a t=0 p>0.05, which shows parallelism. Morelli and Class One present statistically significant differences with t=4.0 p<0.01 and t=2.35 p<0.05, respectively, which suggest divergence in the slot.

Figure 1. Nikon optical comparator used in this study.

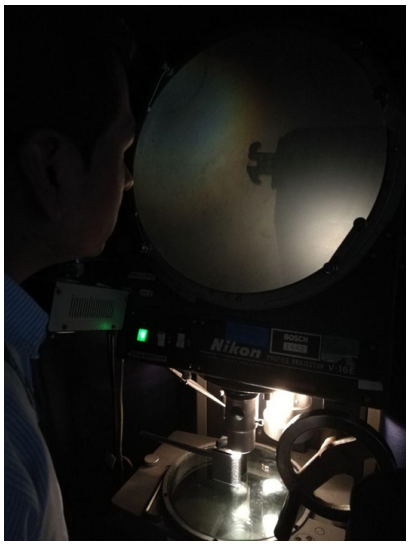


Figure 2. Dimensions of the slot.

A: Vestibular palatal-lingual direction. (Image source: Forestadent.). **B:** Transverse direction. (Image source: Ormco)

Figure 3. Diagram of the methodological process.

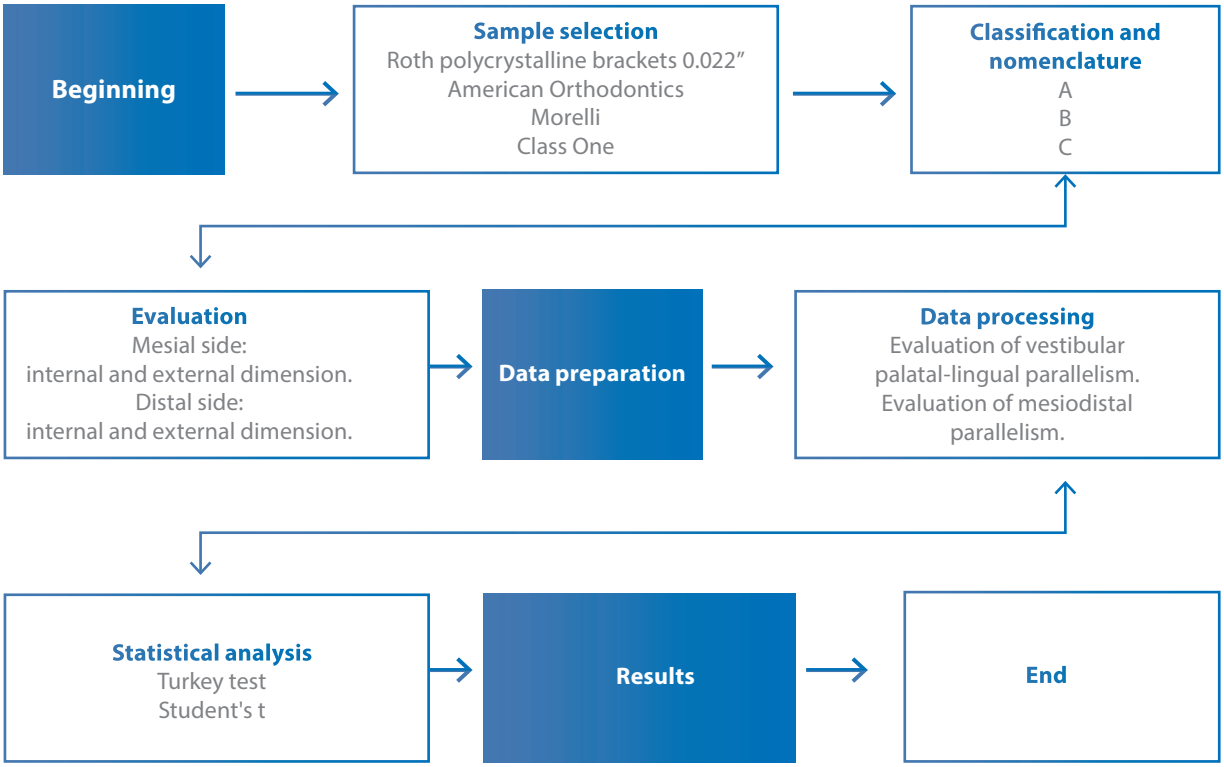
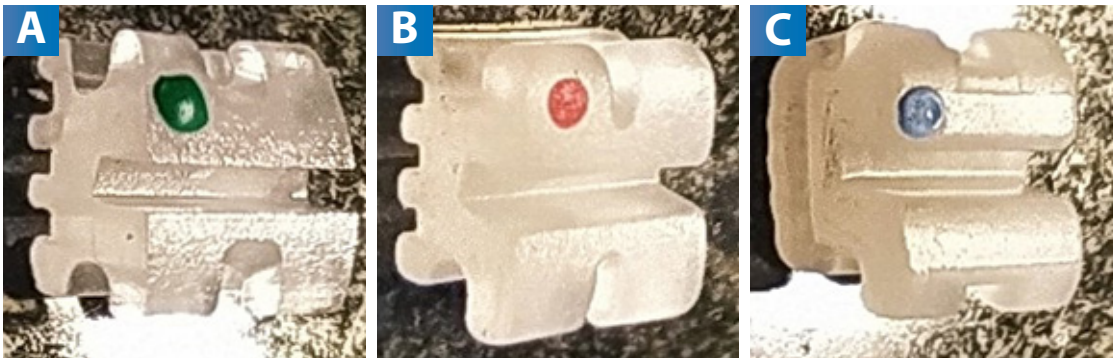


Figure 4. Photograph of polycrystalline ceramic brackets.



A: American Orthodontics. **B:** Morelli. **C:**Class One. (Source: Prepared by the authors.)

Table 1. Reference for data processing.

Direction of evaluation		Parallel	Divergent	Convergent
	Vestibular palatal-lingual	=	< From the base	> From the base
	Mesiodistal	=	< From mesial	> From mesial

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Table 2. Tukey's Multiple Range Test for Comparison of 0.022″ slot measurements by brand.

Brand	Mean	Standard Deviation	Coefficient of variation (%)	Significance (p< 0.01)
American Orthodontics	0.0230	0.0010	4.59	0.00340
Morelli	0.0245	0.0011	4.11	0.00265
Class One	0.0253	0.0015	5.94	0.0000

***p*-value:** (p<0.01). Tolerance range 5% (+/- 0.0011″)

Table 3. Dimensions of the slot in inches and parallelism between the upper and lower walls of the three marks in the vestibular palatal-lingual direction.

Brackets	Internal dimension	External dimension	Parallelism	t-Student
American Orthodontics	0.0228 ± 0.0009 (0.023)	0.0231 ± 0.0011 (0.023)	= (p : 0.765)	0.52 p>0.05
Morelli	0.0244 ± 0.0010 (0.024)	0.0247 ± 0.0009 (0.025″)	< (p : 0.0000)	4.0 p<0.01
Class One	0.0251 ± 0.0016 (0.025)	0.0254 ± 0.0014 (0.026)	< (p : 0.0026)	2.66 p<0.01

= : Parallel. **<:** Divergent. **>:** Convergent.

Table 4. Dimensions of the slot in inches and parallelism between the upper and lower walls of the three marks in mesiodistal direction.

Brackets	Internal dimension	External dimension	Parallelism	t-Student
American Orthodontics	0.0229 ± 0.0005 (0.023)	0.0232 ± 0.0005 (0.023)	= (p : 1.00)	0 p>0.05
Morelli	0.0249 ± 0.0006 (0,026)	0.0243 ± 0.0006 (0.025″)	> (p : 0.0000)	4.0 p<0.01
Class One	0.0253 ± 0.0006 (0.026)	0.0256 ± 0.0007 (0.027)	< (p : 0.0384)	2.35 p<0.05
American Orthodontics	0.0229 ± 0.0005 (0.023)	0.0232 ± 0.0005 (0.023)	= (p : 1.00)	0 p>0.05
Morelli	0.0249 ± 0.0006 (0,026)	0.0243 ± 0.0006 (0.025″)	> (p : 0.0000)	4.0 p<0.01
Class One	0.0253 ± 0.0006 (0.026)	0.0256 ± 0.0007 (0.027)	< (p : 0.0384)	2.35 p<0.05

= : Parallel. **<:** Divergent. **>:** Convergent.

DISCUSSION.

The prescription of a bracket conveys information such as the lingual vestibular inclination (torque),[18] and the mesiodistal angulation.[19] The variety of prescriptions available are aimed at locating the crown and root of the tooth in a specific position according to the treatment objectives. The bracket seeks to transmit the information of the archwire that runs through it and joins it to other teeth, to position it and have a three-dimensional control over the bracket, as when an archwire that fills the slot almost completely is fitted, as it is usually the case with a 0.019 x 0.025" arch in a 0.022 "x 0.028" slot.

The accuracy of this dimension, the play of the arch in the slot, the pressure with which the arch fits into the slot, the bracket location, and the alloy of the arch

and brackets will have to be considered to achieve the planned objectives.[17,20–22] In a medical environment that seeks excellence in patient care and treatment outcomes, it is disappointing to find that, in some cases, the orthodontist's tools may be inaccurately manufactured. The incorrect precision of the slot prevents intimate contact with the archwire, which results in unwanted or unpredictable orthodontic movements.[4,21]

When Cash et al. evaluated the 0.022" slot size of upper left central incisor brackets of various metal, ceramic, and plastic commercial systems, they found that all measurements were oversized, few of them within the tolerance range.[17] In addition, there were many variations with respect to the parallelism of the upper and lower edges of the slots. It is important to consider that many of these brands are from large manufacturers, have international presence, and enjoy great recognition. Their results are similar to those obtained in the present study, but with a greater variation between brands, most likely associated with the quality of the brackets.[17] If a slot is oversized and the 0.019" x 0.025" archwire is placed with the intention of conducting the torque information that is incorporated in the bracket, theoretically the play should only be 10°. Brown et al. found that this play on average reaches 20°, therefore, an effective torque could not be achieved, making it difficult for the root to find the correct position within its alveolar bone.[23,24]

Bhalla *et al.*,[15] evaluated the dimension of the slot of self-ligating metal brackets of 0.022" of the brands 3M, Speed, Ormco, and GAC by means of scanning electron microscopy, and compared them with the measurements of dimension and parallelism published by their manufacturers. They reported that the measurements were greater, and the walls diverged from the bases of the brackets. Their results agree with the results obtained in the present study. But it is important to consider that those brands were not included in this research and are also associated with the complex manufacturing process of a ceramic bracket.

This research also shows highly significant differences ($p<0.01$) between the measurements of the slots of three brands, in contrast to the results of Kancab *et al.*,[25] whose data statistically analyzed with the ANOVA test did not show statistically significant differences ($p<0.05$) between their brands (Ormco, GAC, and 3M Unitek). This could be due to the fact that the studied brackets were metallic and with an explicit guarantee of being free from defects in their material and workmanship.

According to the results obtained regarding the dimensions of the slot and parallelism between the upper and lower walls of the three brands in the vestibular-lingual direction, the walls in the American Orthodontics brackets were statistically parallel; and in the other two bracket designs (Morelli and Class One) they were divergent from the base.

These results coincide with the study carried out by Lugo-Ancona *et al.*,[26] who found that the walls in the Damon system were parallel, and in the other three bracket designs they were divergent from their base. The results of Lee *et al.*,[22] are in agreement with the results of this study; they evaluated the self-ligating ceramic brackets and found that the slots were divergent from the base, that is, the height of the base was less than the height of the external cap in all the brackets studied, which would result in a greater play of the wire and less control of torque. These variations are generally due to the manufacturing process, the polycrystalline ceramic brackets can be manufactured by CNC (milling) or CIM (ceramic injection molding) methods. There are several factors that can affect their quality, such as the ceramic particle size, which when smaller, allows a more rounded and smaller element in addition to having an increased resistance to fracture and provide better translucency. The three brands studied were manufactured by CIM (injected), and as this is a very complex process, alterations in the mold, temperature, or the separation of the ceramic components from the organic ones can cause deformations of the molded parts in the successive stages of removal of additives and sintering.[27]

Archambault *et al.*,[28] carried out a systematic review evaluating the expression of torque by varying the diameter of the slot and the dimension of the final steel arch. They concluded that the coupling angle depends on the dimension of the arch and the shape of the edge, as well as the dimension of the bracket slot, which is variable and greater than the published theoretical values.

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The latter agrees with the results of the present study, and that these may vary more depending on the quality of the brackets to be used. In the 90s, doctors Mc Laughlin, Bennett, and Trevisi (Philosophy and MBT prescription) increased the torque value of the upper central incisor to + 17° with the aim of reducing the loss of torque when trying to correct the overhang in the closure of spaces in order to get closer to the ideal found by Andrews of +7°.[29] Consequently, knowing the torque prescription with which the orthodontist works is of utmost importance for the final position of a tooth.

When Martelli *et al.*,[30] tested and rejected the null hypothesis that there is no difference in the expression of torque between different conventional and self-ligating ceramic aesthetic brackets, indicating that the torque expression was different between the aesthetic brackets evaluated. The height of the slot is directly related to the expression of torque and this was different between the brands,which is in agreement with the variety of dimensions presented in the current work.

In the present study, a wide dispersion was found in the values that compared the dimension of the slot mesially and distally. Only American Orthodontics had statistically parallel slots. Although this factor does not significantly modify the angulation information expressed by the bracket in the tooth when fitting the archwire because the distance between the mesial and distal sides is wide from an orthodontic point of view, it could lead the orthodontist to see the small details in the finish of the brackets that could negatively influence the expected results such as adaptation, incorporated information, surface texture or others associated with friction. An angulation of canines and incisors is directly related to the space they occupy in the arch.[31] It is important for a appropriate functional occlusion and adequate coupling.[32,33]

Therefore, it is imperative to consider that if a slot is oversized or the upper, lower, mesial or distal edges do not show parallelism or geometry, the conduction of the information such as torque and angulation will be altered by the greater play of the arch in the slot in the final stages.[34,35] Consequently considering making individual bends in the final archewires that compensate for these variations should not be ruled out in order to achieve the final objectives.

A limitation is the size of the sample, hence it is not possible to generalize the results obtained.

CONCLUSION.

The results obtained confirm that the slots of the polycrystalline ceramic brackets of the three brands studied are oversized. However, American Orthodontics and Morelli are within the tolerance range. None of the brackets have parallel edges in the buccolingual and mesiodistal direction; however, American Orthodontics does not show statistically significant differences.

The three-dimensional control of the bracket on the tooth could be compromised. Notwithstanding the above, this study has some limitations such as the measurement technique and the sample size, which could be expanded and/or extended to other characteristics, brands, and types of brackets.

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REFERENCES.

1. Alhammadi MS, Halboub E, Fayed MS, Labib A, El-Saaidi C. Global distribution of malocclusion traits: A systematic review. Dental Press J Orthod. 2018;23(6):40.e1-40.e10.
2. Sun L, Wong HM, McGrath CPJ. The factors that influence the oral health-related quality of life in 12-year-old children: baseline study of a longitudinal research. Health Qual Life Outcomes. 2017;15(1):155.
3. Sun L, Wong HM, McGrath CPJ. A cohort study of factors that influence oral health-related quality of life from age 12 to 18 in Hong Kong. Health Qual Life Outcomes. 2020;18(1):65.
4. Alsulaiman AA, Kaye E, Jones J, Cabral H, Leone C, Will L, et al. Incisor malalignment and the risk of periodontal disease progression. Am J Orthod Dentofacial Orthop. 2018;153(4):512-22.
5. Jia M-Y, Hu L-L, Xu Y-J, Song Z-Q, Gu W-Y, Zeng X-M, et al. Logistic regression analysis of risk factors of temporomandibular disorder in undergraduates of Xinjiang Medical University. Shanghai Kou Qiang Yi Xue. 2018;27(5):482-5.
6. Aldrigui JM, Abanto J, Carvalho TS, Mendes FM, Wanderley MT, Bönecker M, Raggio DP. Impact of traumatic dental injuries and malocclusions on quality of life of young children. Health Qual Life Outcomes. 2011;9:78.
7. Laskowska M, Olczak-Kowalczyk D, Zadurska M, Czubak J, Czubak-Wrzosek M, Walerzak M, Tyrakowski M. Evaluation of a relationship between malocclusion and idiopathic scoliosis in children and adolescents. J Child Orthop. 2019;13(6):600-6.
8. Marchena-Rodríguez A, Moreno-Morales N, Ramírez-Parga E, Labajo-Manzanares MT, Luque-Suárez A, Gijon-Nogueron G. Relationship between foot posture and dental malocclusions in children aged 6 to 9 years. Medicine. 2018;97(19).
9. Franco ÉMF, Valarelli FP, Fernandes JB, Cançado RH, de Freitas KMS. Comparative study of torque expression among active and passive self-ligating and conventional brackets. Dental Press J Orthod. 2015;20(6):68-74.
10. Lefebvre C, Saadaoui H, Olive J-M, Renaudin S, Jordana F. Variability of slot size in orthodontic brackets. Clin Exp Dent Res. 2019;5(5):528-33.
11. Naziris K, Piro NE, Jäger R, Schmidt F, Elkholy F, Lapatki BG. Experimental friction and deflection forces of orthodontic leveling archwires in three-bracket model experiments. J Orofac Orthop. 2019;80(5):223-35.
12. Sridharan K, Sandbhor S, Rajasekaran UB, Sam G, Ramees MM, Abraham EA. An in vitro Evaluation of Friction Characteristics of Conventional Stainless Steel and Self-ligating Stainless-Steel Brackets with different Dimensions of Archwires in Various Bracket-archwire Combination. J Contemp Dent Pract. 2017;18(8):660-4.
13. Sheng Y, Guo H-M, Bai Y-X, Li S. Dehiscence and fenestration in anterior teeth: Comparison before and after orthodontic treatment. J Orofac Orthop. 2020;81(1):1-9.
14. Coşkun I, Kaya B. Appraisal of the relationship between tooth inclination, dehiscence, fenestration, and sagittal skeletal pattern with cone beam computed tomography. Angle Orthod. 2019;89(4):544-51.
15. Choi JY, Chaudhry K, Parks E, Ahn JH. Prevalence of posterior alveolar bony dehiscence and fenestration in adults with posterior crossbite: a CBCT study. Progress in Orthodontics. 2020;21(1):8.
16. ISO/IEC 17025 - General requirements for the competence of testing and calibration laboratories [Internet]. International Organization for Standardization. 2017.
17. Cash AC, Good SA, Curtis RV, McDonald F. An evaluation of slot size in orthodontic brackets--are standards as expected? Angle Orthod. 2004;74(4):450-3.
18. Mittal M, Thiruvenkatachari B, Sandler PJ, Benson PE. A three-dimensional comparison of torque achieved with a preadjusted edgewise appliance using a Roth or MBT prescription. The Angle Orthodontist. 2014;85(2):292-7.
19. Topolski F, de O Accorsi MA, Trevisi HJ, Cuoghi OA, Moresca R. Influence of Preadjusted Bracket Shape and Positioning Reference on Angulation of Upper Central Incisor. J Contemp Dent Pract. 2016;17(10):786-90.
20. Bhalla NB, Good SA, McDonald F, Sherriff M, Cash AC. Assessment of slot sizes in self-ligating brackets using electron microscopy. Aust Orthod J. 2010;26(1):38-41.
21. Vieira EP, Watanabe BSD, Pontes LF, Mattos JNF, Maia LC, Normando D. The effect of bracket slot size on the effectiveness of orthodontic treatment: A systematic review. The Angle Orthodontist. 2017;88(1):100-6.
22. Lee Y, Lee D-Y, Kim Y-JR. Dimensional accuracy of ceramic self-ligating brackets and estimates of theoretical torsional play. The Angle Orthodontist. 2016;86(5):804-9.
23. Brown P, Wagner W, Choi H. Orthodontic bracket slot dimensions as measured from entire bracket series. The Angle Orthodontist. 2014;85(4):678-82.
24. Maspero C, Gaffuri F, Castro IO, Lanteri V, Ugolini A, Farronato M. Correlation between Dental Vestibular-Palatal Inclination and Alveolar Bone Remodeling after Orthodontic Treatment: A CBCT Analysis. Materials. 2019;12(24).
25. Kancab Díaz R del C, Ruiz Díaz R, Ruiz Botello G, Olvera SP. Tolerancia en la ranura de brackets .022" x .025" de tres casas comerciales usados en el Postgrado de Ortodoncia de la UNAM. Revista Mexicana de Ortodoncia. 2014;2(3):192-5.
26. Lugo Ancona MA, Ruíz Díaz R, Marichi Rodríguez F, Padilla Olvera S. Variación en el tamaño de la ranura de brackets de autoligado. Revista Mexicana de Ortodoncia. 2015;3(4):224-7.
27. Odriozola A, Ochoa I, Gutiérrez M. Moldeo por inyección de cerámicas. Boletín de la Sociedad Española de Cerámica y Vidrio. 1994;33(5):267-71.
28. Archambault A, Lacoursiere R, Badawi H, Major PW, Carey J, Flores-Mir C. Torque expression in stainless steel orthodontic brackets. A systematic review. Angle Orthod. 2010;80(1):201-10.
29. McLaughlin RP, Trevisi HJ, Bennett JC. Mecánica sistematizada del tratamiento ortodóncico. Ediciones Harcourt. España, 2002.
30. Martelli K, Freitas KM, Negreiros PO, Janson G, Cançado RH, Valarelli FP, de Freitas MR. Comparison of torque expression in esthetic brackets. J Clin Exp Dent. 2019;11(9):e783-e789.

ISSN Print 0719-2460 - **ISSN Online** 0719-2479.

31. Jain M, Vyas M, Singh JR. Effect of Crown Angulation of Maxillary Incisor on Effective Arch Perimeter. J Clin Diagn Res. 2017;11(6):ZC92-6.
32. Tong H, Kwon D, Shi J, Sakai N, Enciso R, Sameshima GT. Mesiodistal angulation and faciolingual inclination of each whole tooth in 3-dimensional space in patients with near-normal occlusion. Am J Orthod Dentofacial Orthop. 2012;141(5):604-17.
33. Castro IO, Frazão Gribel B, Alencar AHG de, Valladares-Neto J, Estrela C. Evaluation of crown inclination and angulation after orthodontic treatment using digital models: Comparison to the prescription of the brackets used. J Orofac Orthop. 2018;79(4):227-34.
34. Dalstra M, Eriksen H, Bergamini C, Melsen B. Actual versus theoretical torsional play in conventional and self-ligating bracket systems. J Orthod. 2015;42(2):103-13.
35. Katsikogianni EN, Reimann S, Weber A, Karp J, Bourauel C. A comparative experimental investigation of torque capabilities induced by conventional and active, passive self-ligating brackets. Eur J Orthod. 2015;37(4):440-6.