



RESEARCH ARTICLE – DENTISTRY (MISCELLANEOUS)

Evaluation of Shear Bond Strength of Natural Teeth Versus Zirconia Crown Using Orthodontic Stainless-Steel Bands (Comparative Study)

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Article Info.	Abstract
<i>Article history:</i>	Back ground: Any disease which leads to loss of tooth structure leads to migration of adjacent teeth in the newly created space. This process leads to impingement of space for the eruption of the succedanea's dentition leading to malocclusions.
Received 10 Jan. 2026	Objective of study: The aim of our study is the evaluation of the ITENA cements as the orthodontic band's cements on zirconium crowns and compare it with the natural teeth.
Revised 10 Feb. 2026	Materials and methods: In the current study, (20) samples were prepared. Natural and zirconia crowns of upper first premolar were performed and used. Performed band was adapted to each tooth. ITENS cement was used, and teeth have been divided into (2) groups: (group A & group B). Orthodontic bands were cemented on natural and zirconia crowns. Before testing, all samples were kept for 24 hrs. at 37°C. All samples were examined in tensile modes by applying the universal testing machines for determining the shear bond's strengths. All samples were visually evaluated at the cement site following the depending process.
Accepted 20 Feb.2026	Results: The values of the maximum shear bond's strength with regard to the maximum loads were shown by natural teeth, and in minimum shear bond's strength for zirconium teeth, a significant variation was shown between the 2 group (p<0.05).
Publishing 10 May. 2026	Conclusions: With regard to maximum loads, the highest values were demonstrated by natural teeth, and lowest by zirconium teeth. This study suggests that the natural teeth were better to use as abutments for space maintainer.

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1. Introduction

In the growth and development of children, deciduous dentitions play essential roles, as they help in chewing speech, aesthetics, onset of oral habit prevention as well as guiding permanent tooth in dental arc [1- 4]. The physiologic procedure of primary teeth shedding and permanent teeth eruption is stopped due to primary teeth's premature loss which may lead to conditions such as arch space reduction, blockade or deflection eruptions of the permanent tooth. The best procedure for prevention of this problem was preserving the deciduous teeth in the arches until their shedding at the usual time because of the functioning of the deciduous tooth as the best maintainers of the space. Therefore, the best potential choice for maintaining the space of the arch is to place a fixed or removable space maintainer [5, 6]. The diverse dietary pattern makes children more vulnerable to caries leading to severe crown's restoration (stainless steel composite or zirconium) [7].

Orthodontic bands are bonded to molars to secure orthodontic appliances or space maintainers to the teeth. In the primary and mixed dentition, the bands were usually attached to the enamel surface of the primary molars, but if the primary molars were restored with stainless steel crowns, they were attached to a metal surface. There are many studies on different types of luting cement used to bond stainless steel band on stainless steel band. With growing general awareness, many parents and even children as young as 3 years are becoming conscious of their appearance. Parents and patients prefer tooth-coloured restoration. Especially, in the last decade, tooth-coloured restoration like zirconia crowns (ZCs) received tremendous popularity due to its superior property over the stainless-steel SSCs. Increasing demand for aesthetic restorations has resulted in increased use of all-ceramic restorations, such as zirconium [8- 11]. Recently, zirconia composite crowns have been widely used as an alternative to stainless steel composite crowns due to their superior aesthetics and durability. For all ceramic crown, zirconia was usually known as the most utilized substances to offer an advantage like biocompatibility, aesthetic appearances and resistances. In dentistry, zirconium

was the strongest and hardest ceramic materials, which was used to display mechanical characteristics in comparison with other metals. In dentistry, using zirconium has seen surges with the CAD-CAM technology development. Zirconium was found in (3) crystallo-graphic forms: the monoclinic structure from (room temperatures & 1170 °C), the tetragonal forms from (1170 °C to 2370 °C) as well as the form of cubic phase structure from (2370 °C and the melting's points of 2680 °C) [12- 14].

Zirconium crowns could be banded to serve as an abutment for maintenance when the adjacent tooth is lost too soon [15, 16]. A paediatric dentist faces a conundrum when the treated teeth were endodontically restored with zirconia and the neighbouring teeth are lost too rapidly. This was when designing a space maintainer becomes crucial. Former studies had mainly concentrated on the band cementation to gold crowns and porcelain denture teeth [17], using a variety of protocols which differed in terms of cement types and surface treatments. A non-significant variation has been found in mean shear peel bond's strength through different protocols in studies related to a band cemented to porcelain denture. Nevertheless, the strongest retentions were demonstrated in a band cemented to the crown of the gold alloy, after using the cements of resin-modified glass ionomer. It has been recommended to use both Glasses Ionomer Cements (GIC) with Resin's Modified GICs (RMGICs) in molar band. For the adherence of orthodontic bands to the teeth or zirconia surfaces with adequate bonding strengths, appropriate cement is required different luting materials exist in markets for SSB cementation; nevertheless, literatures lack the evidence about bond strengths between SSB and ZC that use various luting cements. Thus, the current study was designed for assessing the bond's strengths between ZCs and SSBs that use luting cement in composition with natural tooth.

2. Materials and Methods

2.1. Materials

The material was used in the study are shown in Table1.

Table 1. Materials used in the present study

Materials	Manufacturer	Origin
Stainless steel bands (sized 30)	Premolar bands, with 0.04 inches thickness and 0.15 inches 'width	USA
natural maxillary first molar premolar teeth	Orthodontic clinical in Baghdad	Iraq
zirconia premolar crowns	Milling (CAD_CAM)	Iraq
ITENA cement	MEDICEPT United Kingdom L.T.D, 2 nd floors Hygea House 66 College's Road, Harrows, Middlesex, HA-1 1-BE	UK
Cold cure acrylic resin	Vertex	Holland
Distilled water		Iraq
Stainless steel wire gauge	Dental products	USA

2.2. Methods

2.2.1. Preparing of natural teeth

There are 10 sounds extracted maxillary first premolar, in this study, maxillary first premolar was chosen due to easy to obtained in orthodontic clinics [18]. Inclusion Criteria include Intact enamel, Absence of any cracks due to extractions and Non-carious. Exclusion criteria include existence of any cracks due to extractions and carious teeth.

2.2.2. Preparing of zirconia crown

In this study, intra oral scanner was used to scan maxillary write first premolar and it was converted to STL file (30) Zirconium block as seen in Fig. 1a, was used to mill 10 Zirconium teeth as seen in Fig. 1b [19].

2.2.3. Fabrication of reference model

The teeth were mounted vertically into different letter-coded acrylic blocks (dimensions: 35 mms X 15 mms X 10 mms) [20]. The samples were stored in distilled water to avoid dehydration until bonding procedure was achieved [21]. Acrylic blocks have been coded A for natural teeth "B for zirconia, with different tooth for each of sample's groups. All the teeth received the following treatments (according to manufacturer's recommendation.

2.2.4. Soldering procedure

U_ shape orthodontic wires (1mm Diameter) were soldered (VITA In-Ceram: VITA North America) in mid buccal and mid lingual of SSB to facilitate attachment of band to universal testing machine Fig. 2 [22].



a)



Fig. 1 a) Zirconia block used in the current study, and b) Zirconia teeth

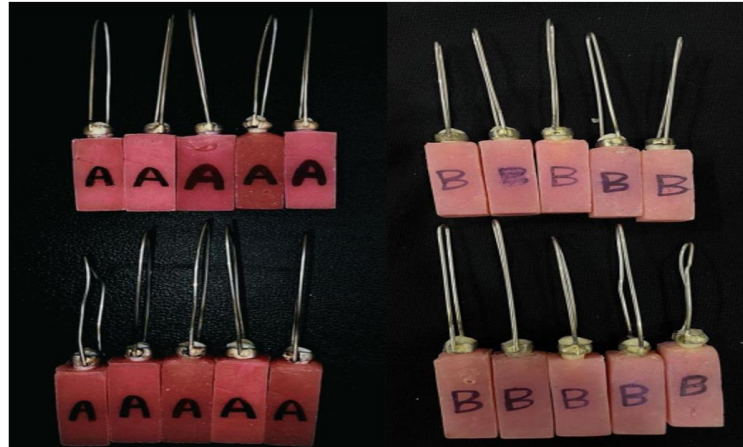


Fig. 2. Orthodontic wires soldered to bands for natural teeth

2.2.5. Stainless steel band's cementation over natural tooth and zirconium crowns

Then the cement was mixed in accordance with the instructions of the manufacturer, which called for a 5-second cementation mixing time. Using an SSB pusher, the bands were manually seated on the crowns after being put onto the SSB's inner surface. Dried cotton rolls were used to scrape away any extra cement from the crown's surface as well as the band's cervical and occlusal borders. The light-curing devices (LED-D Woodpecker's Curing Lights) were used to light-cure ITENA cement for 60 seconds. The cements were left to solidify. Then, the reference models were reserved in the hot-air oven for 24 hours at 37.0°C [23].

2.2.6. Laboratory procedure to determine the bond strength

The test has been performed in the department's lab. of materials engineering in university of technology, Baghdad, Iraq. The test was achieved using a universal testing machine (UTM), specifically being used for dental material bond strength testing. Historically, its origins are linked to the late 19th-century industrial need to test material reliability, particularly for steam power boilers. Each band had pre_solder U_shape wire to facilitate the attachment of band removing apparatus. The sample was secured at the lower jaw of the testing machines and two orthodontic wires were secured in the movable cross head. The testing machine started to move upward until the separation of the band from the tooth. The measurement of applied forces for the band's removal was done in Newton (N), shear bond's strength value was measured and computed in mega Pascal's (MPa), and calculated through division of the peak load's value by the area of the band surfaces (mm²) as shown in Fig. 3.



Fig. 3. Universal testing machine

2.2.7. Adhesive remnant index score

Following de-banding process, the specimens were inspected by a single investigator at the cement site and categorized using a modified version of artun and bergland's adhesive remnant index (ARI) scores [24]. The following was the scoring: Cement covers lower than half of the surface of the crown behind the bands; more than half of the surface of the crown beneath the bands; or all of the crown surface beneath the band 0. No cements remained on the teeth surfaces.

3. Results

In Table 2, descriptive statistics were demonstrated, concerning the test of shear bond strength including (maximum and minimum values, means, SD errors as well as SDs) for banded natural and zirconia teeth. The result showed that the maximum values of mean shear bond's strength testing was (9.75000) for banded natural tooth, whereas the minimum values of mean shear bond's strength testing was (3.38000) for banded zirconia teeth as shown in Table 2.

Table 2. Descriptive statistics of the shear bond strength test for SM bands

Groups	N	Mean	Std. Deviation	Std error	Minimum	Maximum
banded natural tooth (A)	10	9.75000	.789163	.249555	8.700	11.000
banded zirconia tooth (B)	10	3.38000	1.198888	.379122	2.200	5.000
Total	20	6.56500	3.413792	.763347	2.200	11.000

The t-test was done to find any significant variation between two groups. This test demonstrated that there were highly significant variations between groups' values ($p < 0.05$) as observed in Table 3.

Table 3. Comparison of mean for shear bond strength between natural teeth and zirconia teeth using t-test

Groups	T	(P-value)	Sig
Group A& Group B	14.034	.000	(HS)

4. Discussion

The durability of the bond between the orthodontic band and the supporting tooth structure was intrinsically linked to the clinical success of fixed space maintainers. In pediatric dentistry, avoiding malocclusion and permanent tooth deflection after the early loss of primary teeth depends on maintaining the dental arch space. Although natural deciduous teeth have historically been the best at maintaining space, full-coverage restorations are becoming more common due to dental cavities. Because of their better longevity and biocompatibility, zirconia crowns (ZCs) have emerged as a popular aesthetic substitute for conventional stainless-steel crowns (SSCs) in recent years. Ensuring sufficient shear bond strength (SBS) for orthodontic bands cemented to their surfaces was a major difficulty brought about by the move toward these high-strength ceramic materials. A pediatric dentist frequently encounters a "conundrum" when creating a space maintainer for a zirconia-restored tooth. The study's results show that the two substrates examined had significantly different binding strengths ($p < 0.05$). Zirconia teeth (Group B) had a significantly lower mean SBS of 3.38 MPa than natural teeth (Group A), which had a mean SBS of 9.75 MPa. This significant decrease in retention implies that zirconia's non-porous and chemically stable surface does not offer ITENA cement the same degree of chemical adhesion or micromechanical interlocking as natural enamel. Modern literature, such as [17] orthodontic bands glued to their surfaces, echoes these findings. Demonstrates how the type of cement used greatly affects the bond strength to zirconia, frequently necessitating specific luting procedures to get beyond the material's natural resistance to conventional bonding.

Additional examination of the adhesive remnant index (ARI) scores offers vital information on the type of bond failure. Most samples of natural teeth had an ARI score of {2}, meaning that after de banding, more than half of the cement was still on the tooth surface. This implies that failure occurred at the cement-band contact because the link between the cement and the enamel was stronger than the bond between the cement and the metal band in contrast, most zirconia teeth had an ARI score of {0}, meaning that there was no cement left on the tooth surface. This supports the finding that ITENA cement attaches to zirconia less well than natural enamel since it shows a total failure at the cement-zirconia contact.

In order to maximize retention for fixed appliances on diverse restorative surfaces, it is important to assess different adhesive cements, such as Glass Ionomer Cements (GIC) and Resin-Modified GICs (RMGICs), according to recent study by [25] and [15] despite being one of the strongest and hardest ceramic materials used in dentistry, zirconia's efficacy as an abutment for space maintainers seems to be constrained by the typical cementation methods used today. Additionally, research by [21] indicates that over time, adhesive stability may be further impacted by elements including water storage and thermal stressors in the oral environment. In conclusion, our study shows that natural teeth continue to be superior abutments for permanent space maintainers due to their much higher bond strength, even if zirconia offers good mechanical and aesthetic qualities for juvenile restorations [26, 27]. To ensure the functional lifespan of the appliance, clinicians using zirconia crowns should be aware of the increased risk of documentation and look into other luting materials or surface treatments. To close this gap in retentive strength, future studies are advised to investigate various cement types designed especially for use with zirconium abutment teeth in a clinical setting [28]. Bands can be used therapeutically for months or even years [29]. It would be advantageous to track cement retention characteristics after a day, and assessing bond strength in clinical settings is crucial due to a number of factors connected to the oral environment [30].

5. Conclusion

With the limitation of the study, such as n-Vitro Nature, Static Loading, Specific Material Combinations, Sample Size and Variety and finally Lack of long-term data: The study measures immediate bond strength. It does not provide data on how the bond holds up over a typical clinical service period of several months to a year. The highest values of shear bond strength with regard to maximum loads were shown by natural teeth, and lowest shear bond strength for zirconium teeth. With regard to the Adhesive Remnant Index scores reported in the present study, natural teeth show cement failure at cement-band interface, zirconium teeth showed failure of the cement at the interface of cement-enamel. This study suggests that the natural teeth it better to use as abutments for space maintainers. It is recommended to study different types of cement used in fixed space maintainer on zirconium abutment teeth.

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Nomenclature & Symbols	
CAD-CAM	Computer-Aided Design
GICs	Glass Ionomer Cements
NS	Non-significant
RMGIC	Resin-Modified Glass Ionomer
ARI – Adhesive Remnant Index	Adhesive Remnant Index
SSB	Stainless Steel Band
ZCs	Zirconia Crowns

References

- [1] Salama, A. A., Shehab, K. A., & Naguib, A. M. (2026). Evaluation of shear bond strength of orthodontic ceramic and metal brackets with zirconia: effects of adhesive systems and storage conditions. *Clinical Oral Investigations*, 30(4), 131. <https://doi.org/10.1007/s00784-026-06783-1>.
- [2] Casaña-Ruiz, M., Aura-Tormos, J. I., Marques-Martinez, L., Garcia-Miralles, E., & Perez-Bermejo, M. (2025). Effectiveness of space maintainers in pediatric patients: a systematic review and meta-analysis. *Dentistry Journal*, 13(1), 32. <https://doi.org/10.3390/dj13010032>.
- [3] Zou, J., Meng, M., Law, C. S., Rao, Y., & Zhou, X. (2018). Common dental diseases in children and malocclusion. *International journal of oral science*, 10(1), 7. <https://doi.org/10.1038/s41368-018-0012-3>.
- [4] Consolaro, A. (2016). Should deciduous teeth be preserved in adult patients? How about stem cells? Is it reasonable to preserve them? *Dental Press Journal of Orthodontics*, 21(02), 15-27. <https://doi.org/10.1590/2177-6709.21.2.015-027.oin>.
- [5] Babae Hemmati, Y., Neshandar Asli, H., Falahchai, M., & Safary, S. (2022). Effect of different surface treatments and orthodontic bracket type on shear bond strength of high-translucent zirconia: an in vitro study. *International Journal of Dentistry*, 2022(1), 9884006. <https://doi.org/10.1155/2022/9884006>.
- [6] Cantekin, K., Delikan, E., & Cetin, S. (2014). In vitro bond strength and fatigue stress test evaluation of different adhesive cements used for fixed space maintainer cementation. *European journal of dentistry*, 8(03), 314-319. <https://doi.org/10.4103/0970-9290.79979>.
- [7] Barbería, E., Lucavechi, T., Cárdenas, D., & Maroto, M. (2007). Free-end space maintainers: design, utilization and advantages. *Journal of Clinical Pediatric Dentistry*, 31(1), 5-8. doi: 10.17796/jcpd.31.1. p87112173240x80m.
- [8] Kongkiatkamon, S., Rokaya, D., Kengtanyakich, S., & Peampring, C. (2023). Current classification of zirconia in dentistry: An updated review. *PeerJ*, 11, e15669. DOI 10.7717/peerj.15669.
- [9] Setia, V., Pandit, I. K., Srivastava, N., Gugnani, N., & Sekhon, H. K. (2013). Space maintainers in dentistry: past to present. *Journal of clinical and diagnostic research: JCDR*, 7(10), 2402. doi: 10.7860/JCDR/2013/6604.3539.
- [10] Alharbi, F. (2025). Influence of cement type on the bond strength of orthodontic bands to zirconia crowns. *BMC Oral Health*, 25(1), 397. <https://doi.org/10.1186/s12903-025-05615-0M>.
- [11] Raut, A., Rao, P. L., & Ravindranath, T. (2011). Zirconium for esthetic rehabilitation: an overview. *Indian Journal of Dental Research*, 22(1), 140-143. doi: 10.4103/0970-9290.79979.
- [12] Emad, B. (2021). The Effect of Zirconia Band and Loop Space Maintainer On Salivary Level of Lactobacillus and Streptococcus Mutans. *Al-Azhar Journal of Dental Science*, 24(3), 339-344. doi: 10.17796/jcpd.31.1. p87112173240x80m.
- [13] Michailova, M., Elsayed, A., Fabel, G., Edelhoff, D., Zylla, I. M., & Stawarczyk, B. (2020). Comparison between novel strength-gradient and color-gradient multilayered zirconia using conventional and high-speed sintering. *Journal of the mechanical behavior of biomedical materials*, 111, 103977. <https://doi.org/10.1016/j.jmbbm.2020.103977>.
- [14] Klotz, A. L., Halfmann, J., Rues, S., Bömicke, W., Rammelsberg, P., & Zenthöfer, A. (2024). Fracture resistance of posterior tooth-supported cantilever fixed dental prostheses of different zirconia generations and framework thicknesses: An in vitro study. *Materials*, 17(1), 263. <https://doi.org/10.3390/ma17010263>.
- [15] Kalaskar, R., Ijalkar, R., Kalaskar, A., & Balasubramanian, S. (2021). Comparative evaluation of bond strength of different luting cements for cementation of stainless steel bands on primary molar crowns (stainless steel and zirconia crowns): an in vitro study. *International Journal of Clinical Pediatric Dentistry*, 14(6), 762. doi: 10.5005/jp-journals-10005-2003.
- [16] Cantekin, K., Delikan, E., & Cetin, S. (2014). In vitro bond strength and fatigue stress test evaluation of different adhesive cements used for fixed space maintainer cementation. *European journal of dentistry*, 8(03), 314-319. doi: 10.4103/1305-7456.137632.
- [17] Tannure, P. N., Valinoti, A. C., & Maia, L. C. (2009). The use of a natural tooth crown following traumatic injuries in primary dentition. *Journal of Clinical Pediatric Dentistry*, 33(4), 275-278. doi: 10.17796/jcpd.33.4.7358273625861217.
- [18] Alghauli, M., Alqutaibi, A. Y., Wille, S., & Kern, M. (2024). 3D-printed versus conventionally milled zirconia for dental clinical applications: Trueness, precision, accuracy, biological and esthetic aspects. *Journal of Dentistry*, 144, 104925. <https://doi.org/10.1016/j.jdent.2024.104925>.
- [19] AbdElaziz, M. H., Aldamaty, M. F., Omar, E. A., Elbadawy, A. A., Borzangy, S., Alqutaibi, A. Y., & Zafar, M. S. (2024). Fracture resistance of monolithic gradient zirconia crowns with different finish line designs and cement spaces. *Journal of Taibah University Medical Sciences*, 19(6), 1108-1116. <https://doi.org/10.1016/j.jtumed.2024.11.008>.
- [20] Lima, R. B. W., Silva, A. F., da Rosa, W. L. D. O., Piva, E., Duarte, R. M., & De Souza, G. M. (2023). Bonding efficacy of universal resin adhesives to zirconia substrates: systematic review and meta-analysis. *The Journal of Adhesive Dentistry*, 25, b3868649. doi: 10.3290/j.jad.b3868649.
- [21] D'Alessandro, C., Josic, U., Mazzitelli, C., Maravic, T., Graham, L., Barausse, C., ... & Blatz, M. B. (2024). Is zirconia surface etching a viable alternative to airborne particle abrasion? A systematic review and meta-analysis of in vitro studies. *Journal of Dentistry*, 151, 105394. <https://doi.org/10.1016/j.jdent.2024.105394>.
- [22] Herion, T., Ferracane, J. L., & Covell Jr, D. A. (2007). Three cements used for orthodontic banding of porcelain molars. *The Angle Orthodontist*, 77(1), 94-99. <https://doi.org/10.2319/100505-350R.1>.
- [23] Al-Sarkhi, R. A. K., & Al-Groosh, D. H. (2017). The effects of enamel protective agents on shear bond strength after rebonding of stainless steel orthodontic bracket (an in vitro study). *Journal of Baghdad College of Dentistry*, 29(1), 170-176. <https://doi.org/10.12816/0038670>.

- [24] Mao, L., Kaizer, M. R., Zhao, M., Guo, B., Song, Y. F., & Zhang, Y. (2018). Graded ultra-translucent zirconia (5Y-PSZ) for strength and functionalities. *Journal of dental research*, 97(11), 1222-1228. [https://doi.org/10.1016/0002-9416\(84\)90190-8](https://doi.org/10.1016/0002-9416(84)90190-8).
- [25] Kaur, J., Singh, A., Sadana, G., Mehra, M., & Mahajan, M. (2021). Evaluation of shear peel bond strength of different adhesive cements used for fixed space maintainer cementation: an in vitro study. *International Journal of Clinical Pediatric Dentistry*, 14(2), 175. <https://doi.org/10.5005/jp-journals-10005-1932>.
- [26] Aggarwal, M., Foley, T. F., & Rix, D. (2000). A comparison of shear-peel band strengths of 5 orthodontic cements. *The Angle Orthodontist*, 70(4), 308-316. DOI: 10.1043/0003-3219(2000)070<0308: ACOSPB>2.0.CO;2.
- [27] Salama, A. A., Shehab, K. A., & Naguib, A. M. (2026). Evaluation of shear bond strength of orthodontic ceramic and metal brackets with zirconia: effects of adhesive systems and storage conditions. *Clinical Oral Investigations*, 30(4), 131. <https://doi.org/10.1007/s00784-026-06783-1>.
- [28] Uo, M., Sjögren, G., Sundh, A., Goto, M., Watari, F., & Bergman, M. (2006). Effect of surface condition of dental zirconia ceramic (Denzir) on bonding. *Dental materials journal*, 25(3), 626-631. [journal.https://doi.org/10.4012/dmj.25.626](https://doi.org/10.4012/dmj.25.626).
- [29] Ju, G. Y., Lim, B. S., Moon, W., Park, S. Y., Oh, S., & Chung, S. H. (2020). Primer-treated ceramic bracket increases shear bond strength on dental zirconia surface. *Materials*, 13(18), 4106. <https://doi.org/10.3390/ma13184106>.
- [30] Caglaroglu, M., Sukurica, Y., Gurel, H. G., & Keklik, H. (2014). A comparison of shear bond strengths of six orthodontic cements. *Journal of Orthodontic Research*, 2(1), 17. doi: 10.4103/2321-3825.125918.