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Comparison of Alignment Efficiency of Steel Versus Elastomeric Ligatures in Lower Anterior Teeth: A Randomized Clinical Trial

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ABSTRACT

Ligature type influences orthodontic treatment speed, but conclusive evidence comparing alignment time between steel and elastomeric ligatures is limited. **Objective:** To compare the treatment time required by elastomeric ligatures and steel ligatures, in days, to achieve complete alignment of the lower anterior teeth. **Methods:** This randomized clinical trial was conducted at Khyber College of Dentistry, Peshawar, involving 180 participants (90 in each group: steel and elastomeric ligatures). The study included patients aged 12 to 18 years receiving permanent orthodontic treatment with lower premolar extractions and a Little's Irregularity Index of 7-9 mm. Exclusion criteria included systemic conditions, specific dental conditions, and poor periodontal health. Participants were randomly assigned to either the steel or elastomeric ligature group, and the time to reach alignment in the lower arch was recorded. A Student's t-test was used for comparison. **Results:** The age ($p = 0.860$), gender distribution ($p = 0.210$), and age groups ($p = 0.730$) were similar across both groups. The steel ligature group required less time (218.39 ± 10.02 days) compared to the elastomeric group (224.64 ± 9.39 days) ($p<0.001$). This trend was consistent across gender, with both females and males demonstrating notable variations ($p<0.001$ and $p = 0.004$, respectively). The 12–15 years age also showed a notable distinction ($p<0.001$), while the 16–18 years group demonstrated a smaller but still significant difference ($p = 0.016$). **Conclusion:** Stainless steel ligatures required less time to achieve optimal alignment.

INTRODUCTION

It is important to have an efficient treatment approach that yields positive treatment outcomes while reducing the time spent in clinical settings and the overall duration of treatment [1]. The initial stage of fixed appliance therapy involves aligning the teeth, which can vary based on different factors. The biological condition of the tissues plays a crucial role in how orthodontic forces are applied to the periodontium, enabling tooth movement within the alveolar bone [2]. Numerous biological elements, including tooth vitality, cellular and connective tissue response, and periodontal health, are necessary for orthodontic tooth movement to be successful [3]. However, the choice of bracket system and archwire directly influences these biological factors [4]. An optimal ligation technique should guarantee full bracket engagement with the arch wire and exhibit little friction between brackets and the arch wire in order to successfully resolve crowding in orthodontic treatment [5]. In orthodontic treatment, achieving proper alignment of anterior teeth is a key objective [6]. Different ligation methods, such as elastomeric and steel ligatures, have been employed to achieve alignment [7]. Elastomeric ligatures are preferred by orthodontists due to their ease of use and reduced chairside time, but the effectiveness is reduced overtime due to absorption and friction [8]. Steel ligatures on the other hand require manual twisting of wire thereby increasing chairside time but provide effective engagement of wire into bracket slot and provide low friction mechanics [9]. The duration of treatment is an

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important factor for both patients and orthodontists, as it can impact overall treatment efficiency and patient satisfaction. In a study by A study reported the mean treatment time for alignment in elastomeric ligature was 224.95±8.702 days while in steel ligature was 176.15 ± 9.81days [10]. The purpose of this study is to compare the average amount of time needed to align anterior teeth with steel and elastomeric ligatures. By evaluating and analyzing these two commonly used ligation techniques can gain valuable insights into their respective effectiveness in facilitating the alignment of anterior teeth. Owing to the contradictory results of the aforementioned studies this study would put to rest the contradictions. Ultimately, the findings from this study may contribute to informed decision-making regarding ligation methods, optimizing treatment outcomes, and enhancing patient experiences in orthodontic practice. There is lack of research on this topic in Pakistan, so this study will provide local statistics. The results can be variable across different populations due to genetic, ethnic and environmental factors.

Efficient orthodontic treatment aims to achieve optimal tooth alignment within the shortest possible time while maintaining biological safety and patient comfort. Different ligation methods, particularly stainless steel and elastomeric ligatures, are widely used during fixed orthodontic therapy, yet their influence on alignment efficiency remains debated. Previous studies have reported inconsistent findings regarding treatment duration and frictional behavior between these ligation techniques. Moreover, limited clinical trials from Pakistan have evaluated their comparative efficiency, highlighting the need for locally generated evidence to guide orthodontic practice. The objective was to compare the treatment time required by elastomeric ligatures and steel ligatures, in days, to achieve complete alignment of the lower anterior teeth.

METHODS

180 patients (90 each group) participated in this randomised clinical trial, which was carried out at the Department of Orthodontics and Dentofacial Orthopaedics, Khyber College of Dentistry, Peshawar, from September 19, 2024, to May 10, 2025, using a sequential, non-probability sampling procedure. Using OpenEpi software and assuming a mean duration of 224.95 ± 8.7 days for the elastomeric ligature group and 219.95 ± 9.82 days for the steel ligature group, a sample size of 90 participants per group will detect a 5-day difference in mean duration with 95% power at a 5% significance level [10]. Patients aged 12 to 18 years, requiring fixed orthodontic treatment with premolar extractions in the lower jaw, having a Little's Irregularity Index score of 7-9 mm, and not undergoing any additional treatment with functional or orthopedic appliances were included. Patients with systemic conditions, those taking medications affecting tooth movement, and those with missing, impacted, unerupted, fractured, restored, carious, or enamel-defective lower front teeth, as well as those with poor periodontal health, were excluded. The study received ethical approval from the hospital's ethical council, notification number for which is 44/RRB/KCD. The trial was also registered on clinicaltrials.gov and was allotted a registration number: NCT07014332. Participants were recruited from Khyber College of Dentistry's Orthodontics Department if they satisfied the requirements for inclusion. Prior to their enrolment, all participants provided written informed permission after being fully told about the study's goals, methods, possible risks, and advantages. The subjects who fulfilled the inclusion criteria were assigned to one of two groups using the lottery method. Group A received steel ligatures, while Group B received elastomeric ligatures for wire engagement in the brackets. All participants were bonded with metal 0.022" slot MBT pre-adjusted appliances. The archwire order included 0.012 NiTi, 0.014 NiTi, 0.018 NiTi, and 0.019x0.025 NiTi until alignment was achieved. Adjustment appointments were scheduled at six-week intervals. Mandibular dental casts were taken on the day of appliance placement (T1) and again on the day when alignment was reached (T2). Using a Castroviejo calliper, Little's Irregularity Index was computed on the mandibular casts. The alignment time was recorded in days, starting on the day the appliance was placed and ending on the day alignment was attained (T2-T1). All of this information was documented in a predesigned proforma. Little's Irregularity Index was measured as the separation, in millimeters, of the total of horizontal shifts of the mandibular anterior teeth's anatomical points of contact, using a Castroviejo caliper. It was recorded as 0 (Perfect alignment), 1-3 (Minimal irregularity), 4-6 (Moderate irregularity), 7-9 (Severe irregularity), and 10 (Very severe irregularity) [11]. Alignment was defined as a Littles Irregularity Index score of zero, which was calculated by summing the distances (in millimeters) of the horizontal displacements of the anatomical contact mandibular anterior teeth points. Bias and confounders were controlled in the study by closely following to the inclusion/exclusion criteria and through randomization. Effect modifiers, including gender, age, and pre-treatment irregularity, were controlled by randomization. R software version 4.3.3 was used to analyse the data. The mean and standard deviation were calculated for numerical explanatory variables such as age and time to reach alignment. Frequency and percentage were calculated for qualitative explanatory variables like

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gender. To compare the time to alignment (in days) for the steel and elastomeric groups at T2, an independent samples t-test was used. The Shapiro-Wilk test was used to evaluate the data's normality. Post-stratification independent samples t-test was used to control for confounders like age and gender. A p-value was deemed statistically significant if it was less than or equal to 0.050. Figure 1 shows the participant progression CONSORT flow diagram.

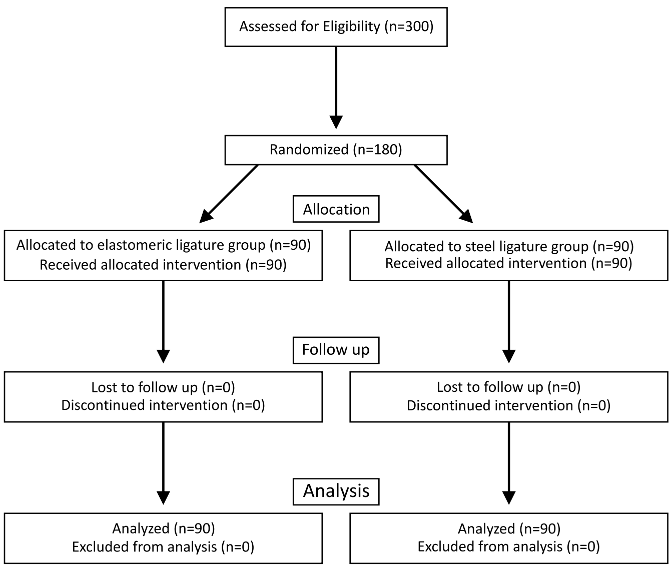

Figure 1: CONSORT Flow Diagram Depicting the Enrollment, Allocation, Follow-Up, and Analysis of Study Participants

RESULTS

The use of parametric analysis was supported by the data's approximate normal distribution (Shapiro-Wilk test: W = 0.993, p = 0.512). The demographic characteristics of the elastomeric group (N = 90) and steel ligature group (N = 90) were similar (Table 1). Mean age was 15.3 (SD 2.13) years for the elastomeric group and 15.2 (SD 2.04) years for the steel group (p = 0.860). Gender distribution did not differ significantly (p = 0.210), with 26.7% females in the elastomeric group and 35.6% in the steel group. Age groups (12–15 vs 16–18 years) were comparable (p = 0.730) (Table 1).

Table 1: Demographic Comparison of Both Groups (n=180)

Characteristics	Elastomeric Ligature Frequency (%)	Steel Ligature Frequency (%)	p-Value
Age	15.3 (2.13)	15.2 (2.04)	0.860*
Gender			
Female	24 (26.67)	32 (35.56)	0.210**
Male	66 (73.33)	58 (64.44)	
Age Groups			
12-15 years	44 (48.89)	47 (52.22)	0.730**
16- 18 years	46 (51.11)	43 (47.78)	

*Student t test; **Chi-square test

The comparison of alignment time (in days) between the two groups revealed that the elastomeric ligature group took significantly longer (224.64 ± 9.39 days) than the steel ligature group (218.39 ± 10.02 days) (p < 0.001). Gender wise, among females, the elastomeric group required significantly more time (227.75 ± 9.54 days) compared to the steel group (218.19 ± 10.45 days), (p < 0.001). Similarly, males in the elastomeric group had a significantly longer alignment time (223.52 ± 9.14 days) compared to the steel group (218.50 ± 9.86 days), (p = 0.004). With respect to age groups, the 12–15 years age group showed a significant difference, with the elastomeric group taking longer (225.18 ± 10.22 days) than the steel group (217.77 ± 9.53 days), (p < 0.001), while the 16–18 years age group showed a smaller but still significant difference (p = 0.016) (Table 2).

Table 2: Time (Days) to Achieve Dental Alignment Overall, By Gender, And Across Age Groups (n=180)

Characteristics	Alignment time (Days)		p-Value*
	Elastomeric Ligature (Mean ± SD)	Steel Ligature (Mean ± SD)	
Overall	224.64 ± 9.39	218.39 ± 10.02	<0.001
Gender			
Female (N = 24 / 32)	227.75 ± 9.54	218.19 ± 10.45	<0.001
Male (N = 66 / 58)	223.52 ± 9.14	218.50 ± 9.86	<0.004
Age Group (years)			
12–15 (N = 44 / 47)	225.18 ± 10.22	217.77 ± 9.53	<0.001
16–18 (N = 46 / 43)	224.13 ± 8.59	219.07 ± 10.59	0.016

**p-values from independent t-tests or equivalent comparisons*

DISCUSSION

The present study examined how efficiently teeth aligned when using either elastomeric or steel ligatures during fixed orthodontic treatment. The results showed a clear and alignment difference that is statistically significant time between the two approaches, both in the overall group and when looking at subgroups based on gender and age. These findings led to the rejection of the null hypothesis, which assumed that there would be no meaningful difference in alignment time between the two types of ligatures. The main finding of this study showed that patients who were treated with steel ligatures had their teeth aligned in significantly less time compared to those who received elastomeric ligatures, although the difference of 7 days is clinically insignificant. On average, the steel group completed alignment in about 218 days, while the elastomeric group took around 225 days, and this difference was statistically significant (p < 0.001). This shorter treatment time with steel ligatures is a clear advantage. When teeth move into position more quickly, patients may spend less time wearing fixed appliances overall, which could reduce the chances of developing problems like gingivitis, white spot lesions, or discomfort [12, 13]. A shorter treatment period can also make it easier for patients to stay motivated and follow their

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orthodontists' instructions [14]. This finding aligns with the results of previous investigations which demonstrated that steel ligatures generate less friction at the bracket-wire interface compared to elastomeric modules [15]. Reduced friction facilitates more efficient transmission of orthodontic forces, thereby enhancing the rate of tooth alignment, particularly in cases of dental crowding [16, 17]. Furthermore, it is reported that elastomeric ligatures are prone to degradation over time due to exposure to saliva and masticatory forces, leading to a decline in their capacity to maintain consistent force levels. In contrast, steel ligatures exhibit superior mechanical stability and are capable of sustaining their force over prolonged periods, making them a more reliable choice in the early stages of orthodontic therapy [18]. In a randomized clinical trial, Soumya *et al.*, compared the efficiency of various ligation methods in aligning mandibular anterior teeth [10]. The study found that the mean time to alignment was significantly longer with elastomeric ligatures (224.95 ± 8.70 days) compared to stainless steel ligatures (176.15 ± 9.81 days). This considerable difference suggested that stainless steel ligatures are more effective in the early stages of orthodontic therapy. Their mechanical stability and resistance to force degradation enable more consistent tooth movement, whereas elastomeric ligatures tend to lose their elasticity over time, which can compromise the efficiency of alignment. In the research carried out by Reddy *et al.*, a direct comparison between different ligation systems revealed important information about the relative efficiency of stainless steel and elastomeric ligatures during the orthodontic treatment's initial alignment phase [19]. Among the five ligation systems evaluated, the study specifically reported that the mean treatment duration to achieve mandibular alignment was 176.3 ± 11.08 days for elastomeric ligatures and 175.56 ± 9.41 days for stainless steel ligatures. Although the difference between these two conventional systems was minimal and not statistically significant, the findings suggest that stainless steel ligatures may offer slightly more consistent performance in reducing friction and maintaining force over time. The subgroup analysis demonstrated that alignment was achieved over a shorter duration with steel ligatures across both genders and age groups, indicating that gender and age did not serve as a significant modifying factor. The effect of faster alignment with steel ligatures was more pronounced in the younger age group, likely due to enhanced tissue remodeling capacity during early adolescence [20]. Given that baseline characteristics such as age, gender distribution, and initial severity of malocclusion were comparable between groups, these findings can be attributed to the ligation method rather than confounding demographic variables.

This study has certain limitations, including its single-center design and the use of non-probability sampling, which may limit the generalizability of the findings. Additionally, only lower anterior alignment time was evaluated, while other treatment outcomes such as patient comfort, plaque accumulation, and long-term orthodontic stability were not assessed. The relatively short observation period also restricted evaluation of complete orthodontic treatment duration. Future multicenter randomized trials with longer follow-up and assessment of additional clinical parameters are recommended to provide more comprehensive evidence regarding the optimal ligation method in orthodontic therapy.

CONCLUSIONS

A significant difference in alignment time was observed between elastomeric and stainless steel ligatures. The findings shown that the type of ligature used can have a big impact on the alignment time. Compared to elastomeric ligatures, stainless steel ligatures take less time to attain ideal tooth alignment.

Authors' Contribution

Conceptualization: AJ, PG
Methodology: AJ, PG
Formal analysis: AJ, PG
Writing and Drafting: AJ, PG
Review and Editing: AJ, PG

All authors approved the final manuscript and take responsibility for the integrity of the work

Conflicts of Interest

All the authors declare no conflict of interest.

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REFERENCES

[1] Kilinc B and Baka ZM. Comparison of the effectiveness of piezocision and microosteoperforation in leveling mandibular anterior teeth. American Journal of Orthodontics and Dentofacial Orthopedics. 2023 Apr; 163(4): 491-500. doi: 10.1016/j.ajodo.2022.02.019.
[2] Li Y, Jacox LA, Little SH, Ko CC. Orthodontic tooth movement: The biology and clinical implications. The Kaohsiung Journal of Medical Sciences. 2018 Apr; 34(4): 207-14. doi: 10.1016/j.kjms.2018.01.007.
[3] Krishnan V, Davidovitch ZE, Kuijpers-Jagtman AM. Biological Orthodontics: Methods to Accelerate or Decelerate Orthodontic Tooth Movement. Biological Mechanisms of Tooth Movement. 2021 Apr: 217-37. doi: 10.1002/9781119608912.ch15.
[4] Kaptaç M and Ay Ünüvar Y. Customized lingual brackets vs. conventional labial brackets for initial

DOI: https://doi.org/10.54393/pjhs.v6i7.3169

alignment: A randomized clinical trial. Journal of Orofacial Orthopedics/Fortschritte der Kiefero-rthopädie. 2022 Sep; 83(5): 307-17. doi: 10.1007/s00056-021-00295-1.
[5] Pithon MM, de O Ruellas AC, Bolognese AM. Rates of tooth movement and bone remodeling activity: Self-ligating versus conventional brackets. Journal of Clinical and Experimental Dentistry. 2020 Apr; 12(4): e391. doi: 10.4317/jced.56615.
[6] Zapata O, Barbosa D, Carvajal A, Ardila CM. Finishing analysis of dental outcome (FADO) as a new guide in orthodontic treatment. Cureus. 2023 Feb; 15(2). doi: 10.7759/cureus.34808.
[7] Skilbeck MG, Mei L, Mohammed H, Cannon RD, Farella M. The effect of ligation methods on biofilm formation in patients undergoing multi-bracketed fixed orthodontic therapy-A systematic review. Orthodontics & Craniofacial Research. 2022 Feb; 25(1): 14-30. doi: 10.1111/ocr.12503.
[8] Elkordy SA, Palomo L, Palomo JM, Mostafa YA. Do fixed orthodontic appliances adversely affect the periodontium? A systematic review of systematic reviews. InSeminars in Orthodontics. 2019 Jun; 25(2): 130-157. doi: 10.1053/j.sodo.2019.05.005.
[9] Elhussein M and Sandler J. Stainless steel ligatures in orthodontic treatment. Orthodontic Update. 2021 Jan; 14(1): 44-7. doi: 10.12968/ortu.2021.14.1.44.
[10] Soumya NB, Manjusha KK, Abin Mohammed BN, Aparna MA, Reyas YR. A prospective randomized clinical study comparing the alignment efficiency of four different ligation methods. IP Indian Journal of Orthodontics and Dentofacial Research. 2023 Jun; 9(2): 117-21. doi: 10.18231/j.ijodr.2023.021.
[11] Balboul DS, Fawzy KM, El Ghoul DH. The validity of Little's irregularity index in the maxillary and mandibular arches.-In Vitro study. Egyptian Orthodontic Journal. 2024 Dec; 66(1): 151-64. doi: 10.21608/eos.2024.307248.1122.
[12] Hussain U, Wahab A, Kamran MA, Alnazeh AA, Almoammar S, Alshahrani SS *et al.* Prevalence, Incidence and Risk Factors of White Spot Lesions Associated With Orthodontic Treatment-A Systematic Review and Meta-Analysis. Orthodontics & Craniofacial Research. 2025 Apr; 28(2): 379-99. doi: 10.1111/ocr.12888.
[13] Li J, Li S, Chen H, Feng J, Qiu Y, Li L. The effect of physical interventions on pain control after orthodontic treatment: A systematic review and network meta-analysis. PLOS One. 2024 Feb; 19(2): e0297783. doi: 10.1371/journal.pone.0297783.
[14] Zhang MJ, Sang YH, Tang ZH. Psychological impact and perceptions of orthodontic treatment of adult patients with different motivations. American Journal of Orthodontics and Dentofacial Orthopedics. 2023 Sep; 164(3): e64-71. doi: 10.1016/j.ajodo.2023.05.021.
[15] Rathinasamy R, Vannala V, Mahabob N, Bhuvaneshwari S, Sam G, Ganapathy A. Evaluation of Frictional Forces Generated between Three Different Ligation Methods with Four Different Sizes of Orthodontic Archwires: An: In vitro: Study. Journal of Pharmacy and Bioallied Sciences. 2021 Nov; 13(Suppl 2): S1434-41. doi: 10.4103/jpbs.jpbs_244_21.
[16] Ebrahimi P, Nastarin P, Hadilou M, Karimzadeh B, Kachoei M. Effect of Elastomeric Module Degradation and Ligation Methods on Kinetic Friction between NiTi or Stainless Steel Wires and Stainless Steel Brackets. Frontiers in Dentistry. 2024 Mar; 21: 10. doi: 10.18502/fid.v21i10.15222.
[17] Khamatkar A, Sonawane S, Narkhade S, Gadhiya N, Bagade A, Soni V *et al.* Effects of different ligature materials on friction in sliding mechanics. Journal of International Oral Health. 2015 May; 7(5): 34.
[18] Bhansali G and Manohar MR. Evaluation of force decay of elastomeric ligatures in simulated oral environment. CODS-Journal of Dentistry. 2018 Sep; 8(2): 74-7. doi: 10.5005/jp-journals-10063-0017.
[19] Reddy VB, Kumar TA, Prasad M, Nuvvula S, Patil RG, Reddy PK. A comparative in-vivo evaluation of the alignment efficiency of 5 ligation methods: A prospective randomized clinical trial. European Journal of Dentistry. 2014 Jan; 8(01): 023-31. doi: 10.4103/1305-7456.126236.
[20] Wang J, Huang Y, Chen F, Li W. The age-related effects on orthodontic tooth movement and the surrounding periodontal environment. Frontiers in Physiology. 2024 Sep; 15: 1460168. doi: 10.3389/fphys.2024.1460168.