Journal of Advanced Zoology
ISSN: 0253-7214
Volume 45 Issue 1 Year 2024 Page 545:560

Comparative Evaluation Of Combination And Conventional Stainless Steel Arch-Wire For En-Mass Space Closure: A Randomized Clinical Study

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Article History

Received:
Revised:
Accepted

Abstract

Aim: To compare and evaluate the rate of space closure by combination stainless steel arch-wire and conventional stainless steel arch-wire for en-mass space closure.
Materials and Methods: Random selection of twenty patients with treatment plan of first premolar extractions was done. After alignment and leveling up to 0.019″ × 0.025″ NiTi archwire a lateral cephalogram and orthodontic study model had been taken as a part of pre-retraction records. Two groups were formed depending on the type of archwire used for extraction space closure. Patients were randomly and equally divided into the two groups with the use of research randomizer software. Group-A: Control group was given conventional rectangular stainless steel arch wire (0.019″ × 0.025″) and Group-B: Experimental group was given combination stainless steel arch wire (0.019″ × 0.025″ (Anterior) / 0.019″ (Posterior). For en-mass retraction force of 200 gm/side was applied with use of NiTi closed coil springs. The springs were engaged from micro implant located between second premolar and first molar to the crimpable hooks positioned distal to the lateral incisor on the archwire. Post-retraction records (lateral cephalogram and study model) were obtained when the remaining extraction space was 0.5 mm. This was done to avoid time delay between the extraction space closure and reporting of the participants.
Results: Proportion of female participant was 80% in conventional arch wire group (Group A) and 70% in combination arch wire group (Group B) .With the help of Bivariate analysis, Chi- square value was observed to be 0.267 found with p value >0.05 which indicated no significant difference in gender distribution between two groups. Independent t- test showed significant reduction in canine distance at pre and post en mass retraction stage with both group. Paired t- test showed rate of retraction with combination arch wire group (0.94 mm/months) (Group B) faster than conventional arch wire group (0.89 mm/months) (Group A). There was no statistical significant difference in the retraction rate between two group.

	Conclusion: En mass retraction rate was faster with the use of combination arch wire when compared with conventional arch wire. In the combination arch wire group, lingual roll -in of molars was found. However, no statistical significance was found between both the groups.
CC License CC-BY-NC-SA 4.0	**Keywords:** En mass retraction, NiTi closed coil spring, Conventional arch wire, Combination arch wire, Mini implant.

Introduction:

Orthodontists through the years have touted the advantages of various application systems.
Central to many of their arguments is the efficiency of tooth movement within short period of time. Orthodontic treatment often demands extraction of first premolar followed by fixed orthodontic therapy necessary for retraction of anterior teeth.
Canines can be retracted either individually or they can be retracted along with the incisors. Retraction of canines along with the anterior teeth as one unit is known as En-mass retraction. There are controversies regarding how to achieve maximum retraction by two step retraction or en-mass retraction with anchorage preservation in premolar extraction cases. Proffit and Fields[1] recommended separate canine retraction followed by incisors retraction for maximum anchorage; stating that this approach would decrease the load on the posterior segment. However, they agreed that closing the space in two steps would take nearly twice as long as closing it in a single step. On the other hand, Staggers and Germane[2]suggested anchorage is being taxed twice with a two-step retraction, as contrasting to once with en masse retraction because of posterior segment is unaware of how many teeth are being retracted and responds to the force acting on it. The debate came to an end when no significant differences were found in the amount of retraction of anterior teeth and the degree of anchorage loss associated with both techniques[3,4]. This fact suggests that en-masse retraction is an adequate alternative to two-step retraction during space closure also given that it is esthetically more acceptable[5].
In En-mass retraction cases, to retract the anterior teeth to the maximum extent, it is of great importance to reinforce maximum posterior anchorage. Creekmore[6] stated that, as a rule of thumb when first premolars are extracted or relieving crowding and incisor retraction, one can expect the posterior teeth to move forward around one third of the space. A dental anchorage expresses a certain degree of anchor loss hence there is a need to use devices that do not use teeth as anchorage units. With the introduction of micro-implants, it has become possible to achieve absolute anchorage during anterior teeth retraction[7, 8].
Space closure is often done either by Friction or Frictionless mechanics. Frictional mechanics is that the sliding of a tooth along an arch-wire by application of force.[9]Frictionless mechanics uses loops for space closure. Although the force exerted in frictionless method is usually ideal but the fabrication and usage of loops is intricate and biomechanically challenging. Thus, they are less popular nowadays[10, 11]. However,frictional mechanics allows orthodontic space closure by sliding[11]. The sliding mechanics for en-mass retraction has gained a substantial popularity after the introduction of MBT philosophy[12].In sliding mechanics, space closure is carried out with the help of either E-chain, NiTi closed coil spring or stretched modules with ligatures. Nickel – Titanium closed coil springs have been shown to produce a constant force over varying lengths and duration, with no force decay. They may be able to meet all the criteria for an ideal force delivery system[13].
Friction consumes a considerable degree of energy during retraction which increases the force requirement as well as mechanical taxing of the anchorage unit. Anchorage control is significant for good outcome. The most challenging situation is to achieve en-mass retraction minimal or no anchorage loss[14, 15]. Thus, Temporary Skeletal Anchorage Devices (TADs) were introduced for biomechanical therapy and are commonly used in contemporary orthodontics.With the use of micro-implant (TADs) it is possible to achieve absolute anchorage[16, 17, 18]
Accelerating rate of orthodontic tooth movement should be considered as one of the important challenges to be worked upon by orthodontists. Peter Ziegler[19] found that rectangular arch-wires have adversely affected the speed of the tooth movement through increased binding and friction. Whereas round stainless steel arch wires have greater clearance within the bracket slot thus leading to lesser friction compared to heavy rectangular stainless steel arch wiresbut have only two dimensional control over teeth[20]. To avoid the undesirable effects of conventional rectangular arch-wire or round wires, combination arch-wire can be used. Combination arch-wire[21] is rectangular in anterior segment to maintain torque and round in posterior segment to allow sliding mechanics with reduced friction and increased rate of retraction. It is desired by every orthodontist to improve the rate of orthodontic space closure with minimum anchor loss. Thus, this study evaluates use of combination

arch-wire along with micro implant anchorage as a promising option for simultaneous en-mass retraction of anterior teeth and extraction space closure.

AIM AND OBJECTIVES

Aim of the study:
• To compare and evaluate the rate of space closure by combination stainless steel arch-wire and conventional rectangular stainless steel arch-wire for en-mass space closure.

Objectives of the study:

1. To evaluate the rate of space closure by the use of combination stainless steel arch-wire for enmass retraction
2. To evaluate the rate of space closure by the use of conventional rectangular stainless steel archwire for en-mass retraction.
3. To compare the rate of space closure between combination stainless steel arch-wire and conventional rectangular stainless steel arch-wire for en-mass retraction.

MATERIALS AND METHODS

Study design: Randomized Clinical Study
Ethical approval: The ethical approval to conduct study was obtained from Sumandeep Vidyapeeth Institutional Ethical committee (SVIEC) on 23/01/2019. (Annexure I)
Place of the study: Study was conducted in Department of Orthodontics and Dentofacial Orthopaedics, K.M. Shah Dental College and Hospital, Sumandeep Vidyapeeth Deemed to be university.
Source of sample: Participants undergoing orthodontic treatment, involving extraction of all maxillary first premolar and in whom levelling and aligning stage has been accomplished and retraction has to be started, in department of Orthodontics and Dentofacial Orthopaedics, were considered for the study.

Sample description:
Sample size calculation was based on the previous study done by Asim Ghouse Basha[15]. The minimum required sample size for study was 16 to estimate mean difference in space closure between two groups by 0.28 mm with SD of 0.2 mm at 95% confidence and 80% power.
Using the formula: $N = 2^{*}(Z^{2}\,{}^{*}SD^{2})/d^{2}$
Where,
Z = value of z from normal distribution table = 2.820 SD = standard deviation as given above =0.2 mm d = mean difference as given above =0.28 mm
For the present study 20 participants were selected out of which 10 each were allocated in Experimental Group and Control Group respectively.
Experimental group was treated with combination stainless steel archwire.
Control group was treated with conventional rectangular stainless steel archwire.

Sample selection criteria:
(A) Inclusion criteria:
1. Participants requiring therapeutic extraction of maxillary first premolars as a part of fixed orthodontic therapy.
2. Participants in whom aligning and levelling stage has been accomplished.
3. Participants above 17 years of age.

(B) Exclusion criteria:
1. Participants with any systemic illness.
2. Participants with compromised periodontium.
3. Participants with any missing teeth anterior to first permanent molars 4. Participants requiring orthognathic surgery as a part of orthodontic treatment
5. Participants with history of previous orthodontic treatment.

Equipments used in the study:

1. Mini implant driver (S. K. Surgical)
2. Varnier calliper
3. Dontrix gauge (Leone, USA)

Materials used in the study:

1. Orthodontic brackets with MBT 0.022 slot prescription (AO)
2. Combination stainless steel archwire- 0.019″ × 0.025″ (Anterior) / 0.019″ (Posterior) (G&H orthodontics, USA)
3. Conventional rectangular stainless steel archwire- 0.019″ × 0.025″(KODEN , USA)
4. Ni-Ti closed coil spring (Dentos, India)
5. Crimpable hooks (Dentos, India)
6. Alginate impression material (Imprint)
7. Periodontal probe (GDC)
8. Local anesthetic spray (Nummit spray, ICPA)
9. Class III Dental stone (Orthokal)

Methodology:

This study was conducted after obtaining ethical approval from Sumandeep Vidyapeeth Institutional Ethical Committee (Approval no: SVIEC/ ON/ Dent/ BNPG18/ D 19010) (Annexure I). Participants were selected according to the inclusion criteria. Participant information sheets were given to the participants after explaining the procedures of the study in detail (Annexure II) and a signed written informed consent was obtained from the participants (Annexure III). Twenty patients requiring therapeutic extraction of maxillary first premolars as a part of fixed orthodontic mechanotherapy had been randomly selected. After alignment and levelling upto 0.019″ × 0.025″ NiTi archwire (Figure 1)

FIGURE 1

a lateral cephalogram and orthodontic study model had been taken as a part of pre-retraction records. Two groups were formed depending on the type of archwire used for extraction space closure. Patients have been randomly and equally divided into the two groups with the use of research randomizer software (Figure 2).

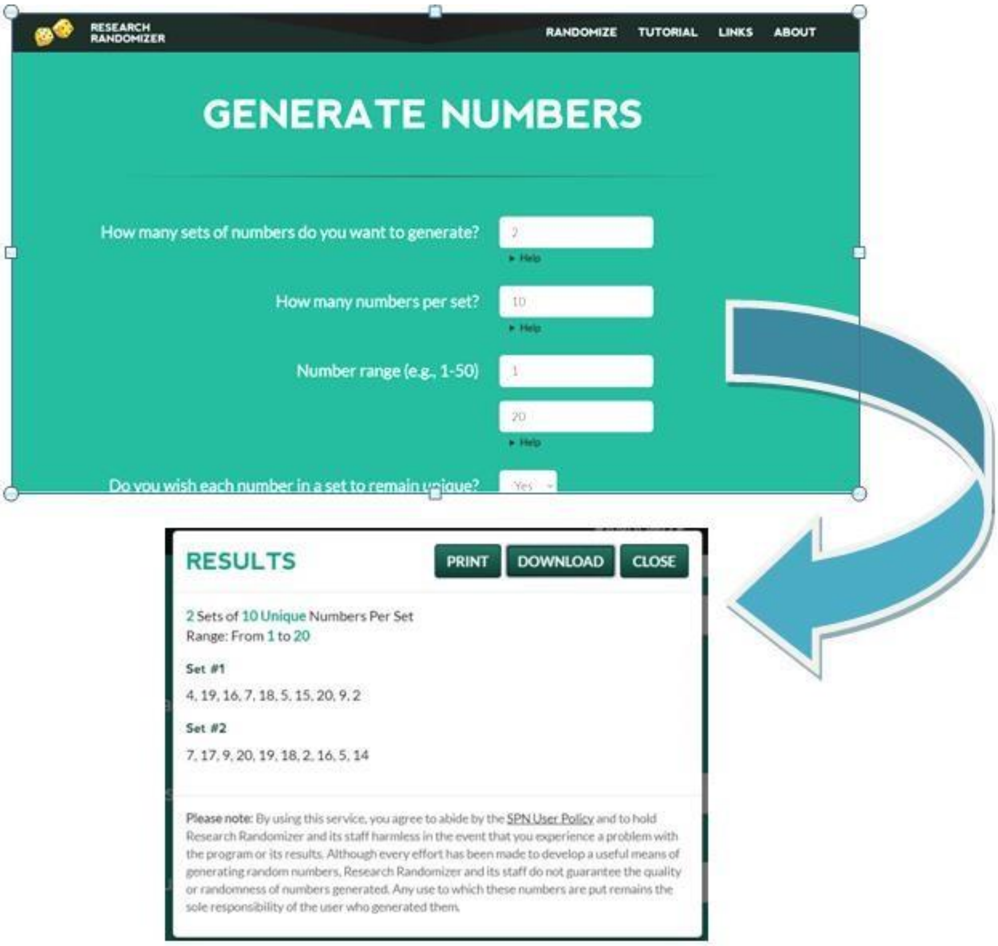


FIGURE 2

Group-A: Control group were given conventional rectangular stainless steel archwire (0.019″ × 0.025″) and Group-B: Experimental group were given combination stainless steel archwire (0.019″ × 0.025″ (Anterior) / 0.019″ (Posterior). Crimpable hooks were positioned on the arch wire distal to lateral incisors in both the groups, for retraction. (Figure 3)

FIGURE 3

Surgical Stainless steel micro implants (1.3 mm in diameter and 8 mm in length; SK Surgical, Pune, India.) were placed between the roots of first molar and second premolar in the upper arch to achieve absolute anchorage for retraction. Micro implants of self-drilling type were used. Periodontal probe was used to get a purchase point at the predetermined area of micro screws insertion to facilitate implantation which was 7 mm above the margin of interdental gingiva on the attached gingiva. (Figure 4)

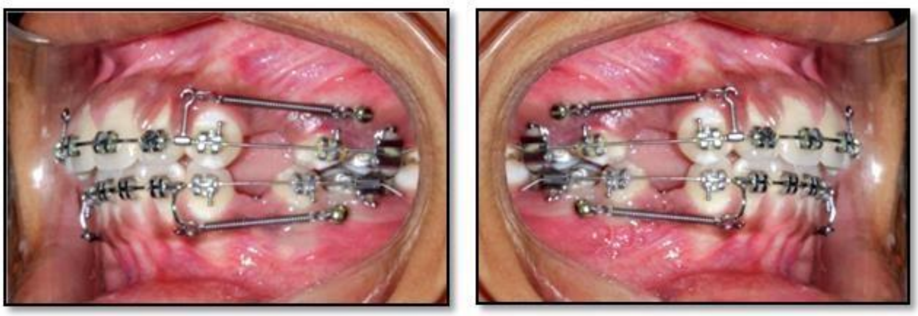
FIGURE 4

After topical application of local anesthetic spray in the region of micro implant insertion, the micro implants were placed using a straight driver between maxillary second premolar and first molar on both side (Figure 5).

FIGURE 5

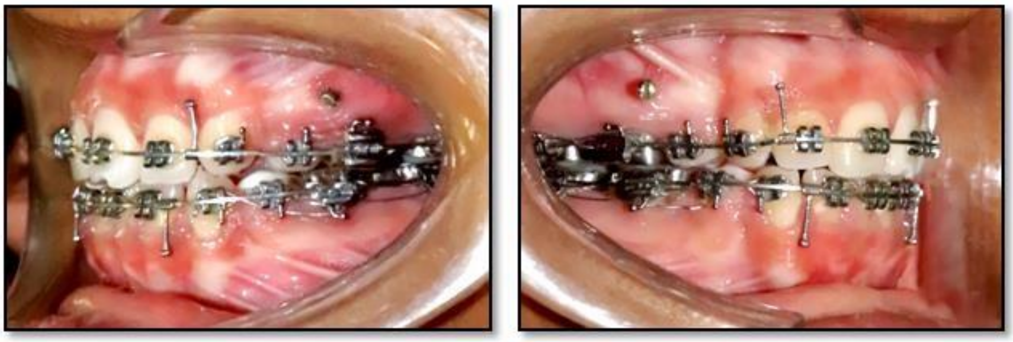
For en-mass retraction NiTi closed coil springs were used. A force of 200 gm / side was applied, as measured on the Dontrix gauge (Leone, USA), has been applied for retraction. The springs were engaged from micro implant located between second premolar and first molar to the crimpable hooks positioned distal to the lateral incisor on the archwire. Patients were recalled every month for follow up until the entire extraction space was closed. (Figure 6)(Figure 7)

En-mass retraction on conventional arch wire (Group A)

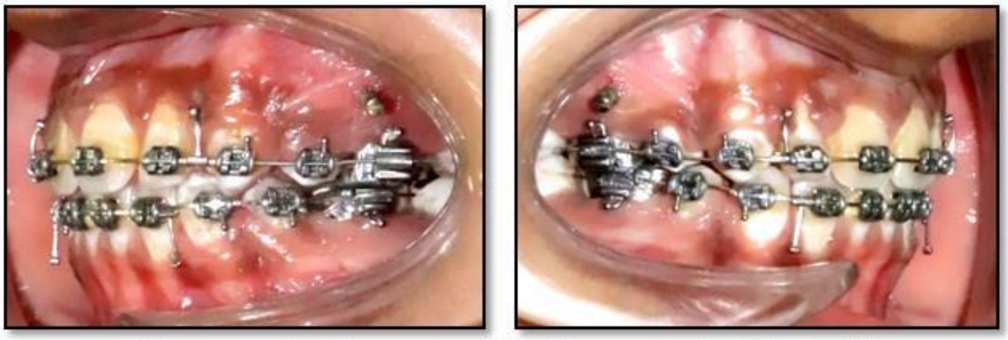


En-mass retraction on combination archwire (Group B)

FIGURE 6



En-mass retraction on conventional arch wire (Group A)



En-mass retraction on combination arch wire (Group B)

FIGURE 7

Methods of taking pre and post retraction records with their assessment protocols

1. Cephalometric assessment:
Lateral cephalogram had been taken as pre and post retraction records in both the groups. All the lateral cephalograms were evaluated by co-investigator who was blinded. To differentiate the right and left sides on the lateral cephalogram, guides made of 19″× 25″ SS wires were placed on canine brackets for both the sides. The guides were triangular shaped on left side and square shaped on right side. (Figure 8)

FIGURE 8

The same guide was used for the post-retraction cephalogram. The vertical segment of the guide represented position of the canine. The amount of retraction had been measured by the linear distance between the guide and the line perpendicular to SN plane passing through the Sella[8]. (Figure 9)

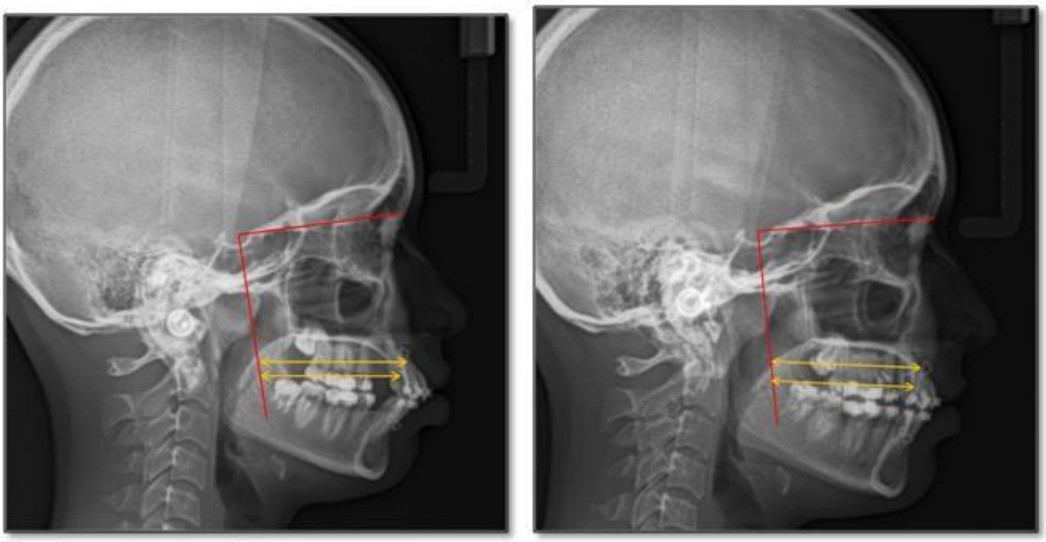


FIGURE 9

The total amount of retraction was calculated by the difference between the pre-retraction and postretraction measurements between the guide and the perpendicular plane to SN point. The average of both right and left side was taken as final measurement.

2. **Study model assessment:**
After making alginate impression, the study model had been prepared using orthodontic stone class III (Orthokal) as a part of both pre and post retraction record. All the study models were evaluated by co-investigator who was blinded. The amount of space closure had been calculated by comparing both the pre and post retraction study models. The space between distal surface of canine and mesial contact point of first permanent molar was measured for both the sides with Varnier calliper on pre and post retraction record (Figure 10).

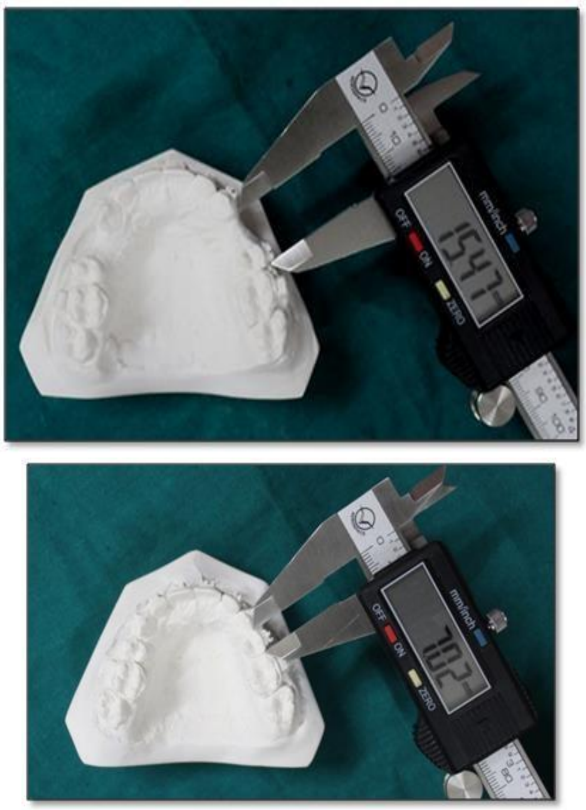


FIGURE 10

The average of both right and left side were taken as final measurement.
The entire methodology has been summarized in the flowchart. (Chart 1)

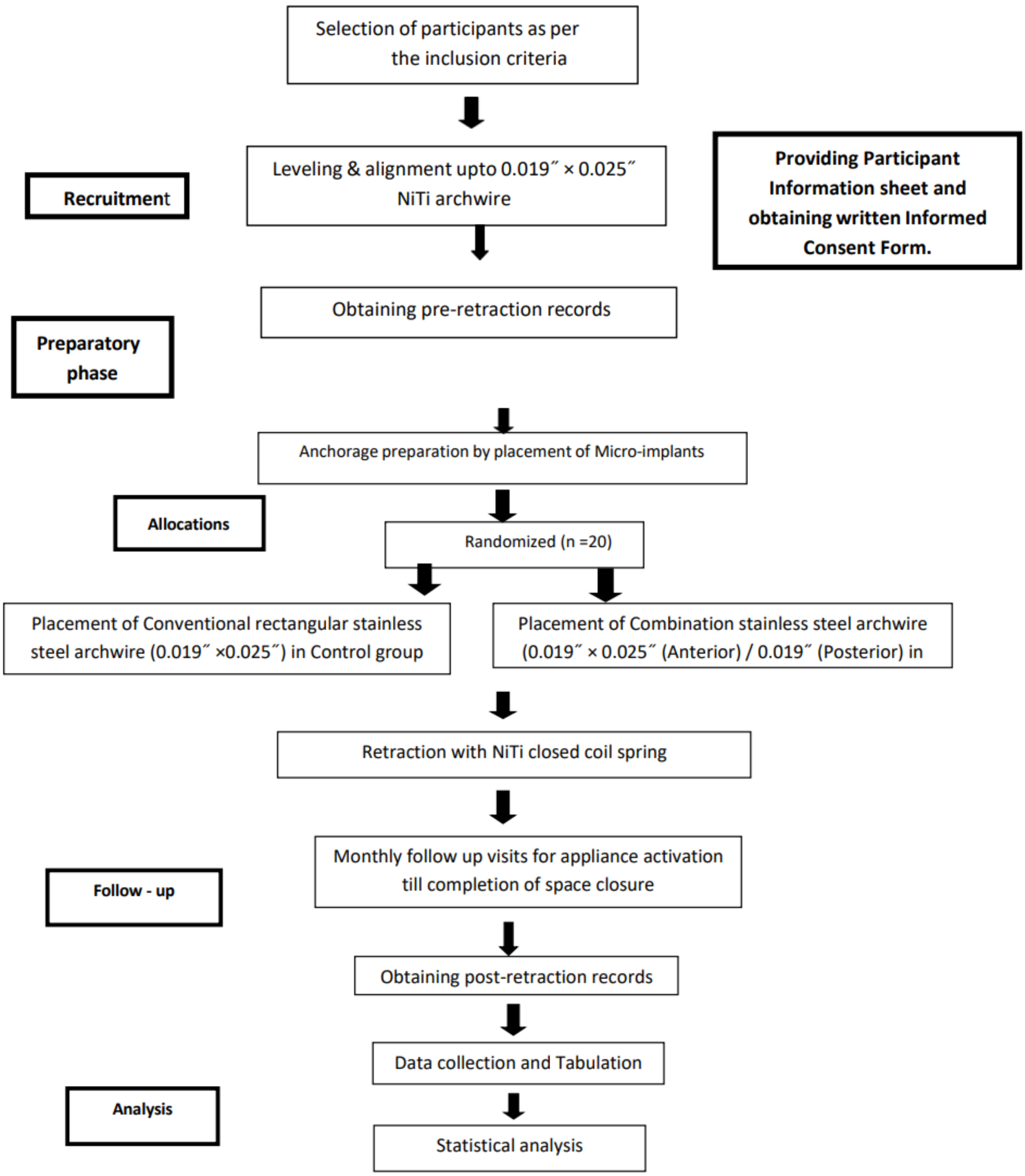


CHART 1: Consort flow chart showing methodology

OBSERVATION AND RESULTS

The present study was carried out to compare rate of en mass retraction between combination arch wire and conventional arch wire. Results were based on analysis of total 20 numbers of patients with the mean age 22.6 ± 3.85 years. Proportion of female participant was 80% in conventional arch wire group (Group A) and 70% in combination arch wire group (Group B) With the help of Bivariate analysis, Chi- square value was 0.267 found with p value >0.05 which indicated no significant difference in gender distribution between two groups.(Chart 2)

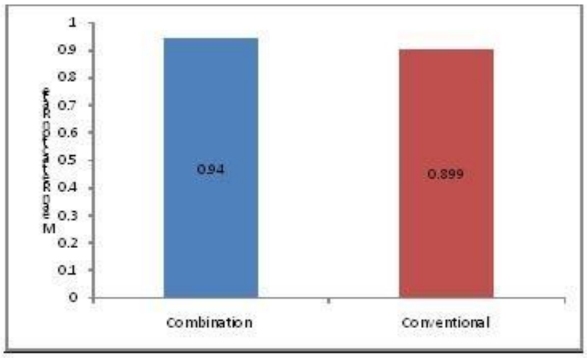


CHART 2

Average Distance	N	Mean(mm)	Std. Deviation(mm)
Lateral Cephalogram Pre-retraction	10	57.35	1.313
Lateral Cephalogram Post-retraction	10	50.42	1.819
Study Model Preretraction	10	14.32	0.538
Study Model Postretraction	10	7.34	0.161

Table 1: Distance of canine at pre and post retraction stages in conventional arch wire group (Group A)

Table 1 show the distance of canine on true vertical plane to SN on lateral cephalogram and the distance of canine to mesial contact point of molar on study model at pre and post-en mass retraction stage with conventional arch wire group (Group A). Table 2 and chart 3 shows significant reduction in canine distance at pre and post en mass retraction stage with conventional arch wire group.

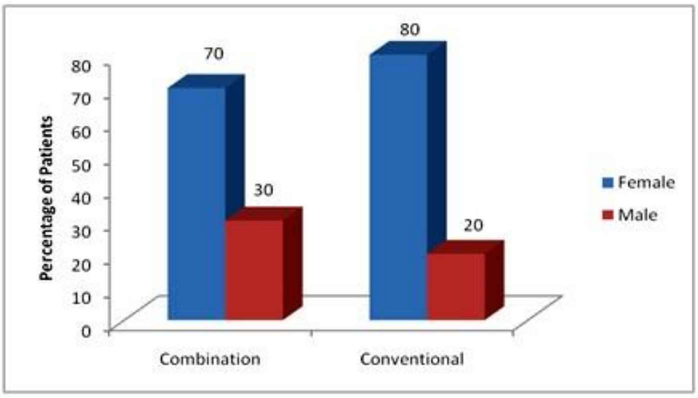


CHART 3

Pre to Post Retraction Average Distance Reduction	Mean(mm)	Std. Deviation(mm)	Std. Error Mean	95% Confidence Interval of the Difference		t-value	df	p-value
				Lower	Upper			
Lateral Cephalogram	6.930	0.745	.201	4.796	5.704	29.412	9	<0.001
Study Model	6.980	0.585	.185	6.565	7.401	37.660	9	<0.001

Table 2: Comparison between distance of canine at pre and post retraction stages in conventional arch wire group (Group A)

Average Distance	N	Mean(mm)	Std. Deviation(mm)
Lateral Cephalogram Pre-retraction	10	57.45	1.877
Lateral Cephalogram Post-retraction	10	50.23	1.923
Study Model Pre-retraction	10	14.40	0.529
Study Model Post-retraction	10	7.16	0.262

Table 3: Distance of canine at pre and post retraction stages in combination arch wire group (Group B)

Table 3 shows the distance of canine on true vertical plane to SN on lateral cephalogram and the distance of canine to mesial contact point of molar on study model at pre and post-en mass retraction stage with combination arch wire group (Group B). Table 4 and chart 4 shows significant reduction in canine distance at pre and post en mass retraction stage with combination arch wire group.

Pre to Post Retraction Average Distance Reduction	Mean(mm)	Std. Deviation(mm)	Std. Error Mean	95% Confidence Interval of the Difference		t-value	df	pvalue
				Lower	Upper			
Lateral Cephalogram	7.215	0.609	0.539	3.982	6.418	37.356	9	<0.001
Study Model	7.237	0.596	0.188	6.811	7.663	38.393	9	<0.001

Table 4: Comparison between distance of canine at pre and post retraction stages in combination arch wire group (Group B)

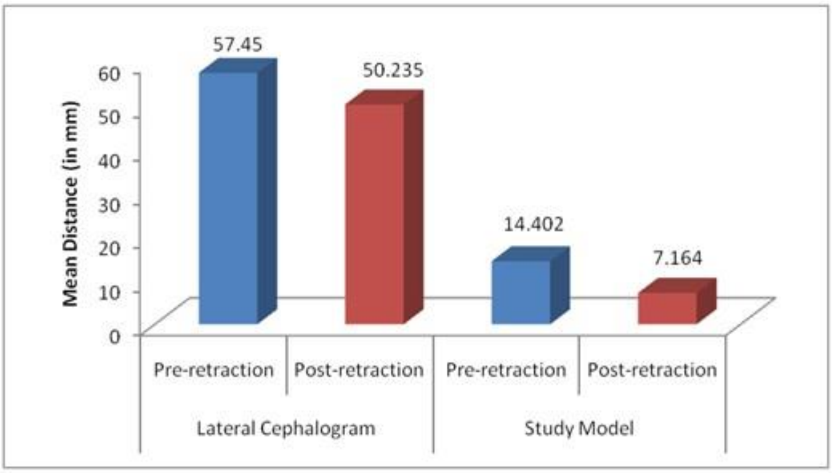


CHART 4

Average Distance	Type of Wire used for Retraction	N	Mean(mm)	Std. Deviation(mm)	t-value	p-value
Lateral Cephalogram	Conventional	10	6.9300	0.74506	0.936	0.361
	Combination	10	7.2150	0.60921		
Study Model	Conventional	10	6.9805	0.58605	0.972	0.344
	Combination	10	7.2375	0.59615		

Table 5: Comparison between amount of en mass retraction with conventional (Group A) and combination arch wire group (Group B)

Table 5 shows comparison between amount of en mass retraction on study model and lateral cephalogram with conventional (Group A) and combination arch wire group (Group B). Amount of en mass retraction was statistically and clinically insignificant between two groups. Table 6 and chart 5 shows comparison of en mass retraction rate between two groups which shows no significant difference in the retraction rate.

	Type of Wire used for Retraction	N	Mean(mm)	Std. Deviation(mm)	t-value	p-value
Retraction Rate	Conventional	10	0.899	0.079	-1.150	0.265
	Combination	10	0.940	0.080		

Table 6: Comparison between en mass retraction rate with conventional (Group A) and combination arch wire group (Group B)

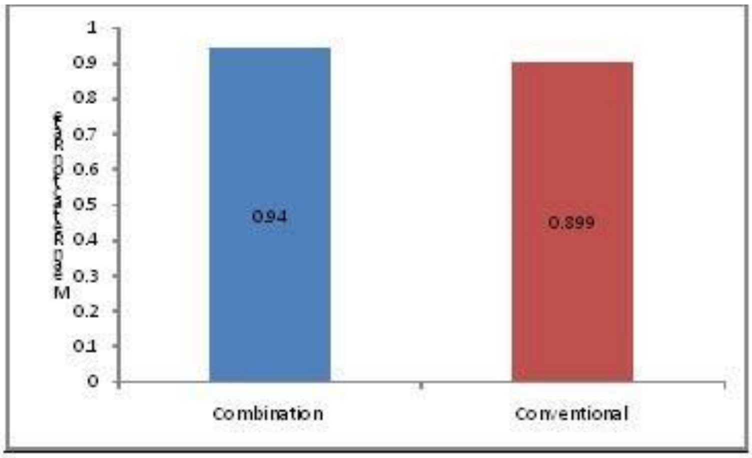


CHART 5

DISCUSSION

Extracting the first premolars and retracting the anterior segments with maximum anchorage is an effective way to reduce lip protrusion and to straighten the patient's profile. In premolar extraction - based orthodontic treatment, retraction of anteriors is the most timeconsuming. Any procedure which reduces the time required to perform this stage will also help to shorten the overall treatment time.

The rate of tooth movement during orthodontic treatment depends on various factors. For example, the alveolar bone density[48], formation of hyalinized tissue adjacent to the root due to the application of excessive mechanical force[49], or the discontinuation of force application[50] causing an interruption of the initial strain-lag phase undermining resorption cycle of tooth movement[51], as well as the magnitude of force applied[52]. Differences in the methodology of force application are proposed to maximize the speed of orthodontic treatment while eliciting a biologically sound response.

Sliding mechanics for En-masse retraction has become more common with increased use of pre-adjusted appliances. It has been observed that attempts to retract the six anterior teeth simultaneously results in loss of anchorage[53]. However, with the advent of absolute anchorage devices has become more practical to retract the six anterior teeth simultaneously in one step rather than two steps. With the use of mini-screw implants clinicians can retract six anterior teeth altogether without anchorage loss in pre-adjusted edgewise appliances.[54]

Advances in implant dentistry make it possible to use implants for anchorage in adult orthodontic patients. Much of literature has proven the clinical efficacy[, 55,56,57,58] and stability[56, 59] of temporary orthodontic skeletal anchorage devices. With the use of mini implant maximum en mass retraction of anterior teeth is possible without patient compliance and makes better system for controlling without molar slippage or extrusion. In present study, success rate with mini implant was 90 % since failure was observed of implant in 2 patients in the initial stage of study. Micro implants were replaced after 3 weeks of start of treatment. All implants showed primary stability at placement and were loaded immediately with NiTi closed coil spring. Inflammation was least so did not interfere with the retraction of the anterior teeth. Hence, with the help of mini implant, closure of extraction spaces was completely done by retraction of anterior teeth.

Excessive forces during treatment can cause apical root resorption, particularly when heavy continuous forces are used[60]. However, in this study physiologic (150-200 g) forces were subjected with pre-calibrated nickel-

titanium closed coil springs using implants for en-masse retraction. Due to the group movement of the teeth, forces were equally distributed along the root surface area and thus did not concentrate at one point.
Various protocols using different wires and brackets have been developed to control tooth movements, such as biometric and bi-dimensional systems[61, 62]. These systems concern posterior “play” and three-dimensional control of anterior teeth during space closure[63]. Several factors influence the choice of arch wire progression, such as personal preference, cost, and wire characteristics for ideal tooth movement. Normally en mass retraction is done on conventional 19*25 S.S wire due to good three dimensional control over teeth[63].Peter Ziegler[19] found that rectangular arch-wires have adversely affected the speed of the tooth movement through increased binding and friction. Retraction of anteriors includes relative motion of brackets with the arch wire which generates friction and binding. If these frictional forces are excessive it may lead to dissipation of forces which limit tooth movement, this fact is observed with heavy rectangular stainless steel archwires[64]. Round stainless steel arch wires have greater clearance within the bracket slot thus leading to lesser friction compared to heavy rectangular stainless steel arch wires[20]. But round arch wires give control in two planes only.
To avoid the undesirable effects of conventional rectangular arch-wire, combination archwire can be used. Combination arch-wire[21] is rectangular in anterior segment to maintain torque and round in posterior segment to allow sliding mechanics with reduced friction and increased rate of retraction. It is desired by every orthodontist to improve the rate of orthodontic space closure with minimum anchor loss. Thus, this study evaluates use of combination arch-wire along with micro implant anchorage as a promising option for simultaneous en-mass retraction of anterior teeth and extraction space closure.
Fatima Hamid et al[47] compared the mean rate of canine retraction on round and rectangular stainless steel arch wires. This was split mouth study with customized arch wires. They found that mean rate of canine retraction was greater with round arch wire compared to rectangular arch wire. There was 3% of distal tipping of canines with round arch wires. In the present study the amount of en mass retraction in the two groups was comparable with no statistical significance. However, rate of retraction with combination arch wire group (0.94 mm/months) (Group B) was observed to be faster than conventional arch wire group (0.89 mm/months) (Group A). Faster retraction rate could be due to round configuration of combination wire in the posterior segment which allowed more play of the wire and less binding to the brackets of posterior teeth. It was helpful to slide wire with less friction comparative to rectangular wire and enhance the retraction rate. Due to the round configuration of wire in posterior segment, there was a significant torque loss in molars with combination arch wire. However, in both the group, there was good three dimensional control over anterior segment with rectangular configuration of wire and proper retraction mechanics.

CONCLUSION

En mass retraction rate was comparatively faster with the use of combination arch wire compared to conventional arch wire but the difference was statistically insignificant. Also with the combination arch wires, lingual roll-in of molars was recorded.

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