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Original Article

Comparison of the Pendulum appliance and the Jones Jig: A prospective comparative study

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ABSTRACT

Objective: To compare two molar distalization devices, the Pendulum appliance (PA) and the Jones Jig (JJ) in dental Class II patients. **Materials and Methods:** Pretreatment and postdistalization lateral cephalograms and study models of 20 subjects (6 males, 14 females) Class II malocclusion subjects were examined. PA and JJ group both consisted of 10 patients each with a mean pretreatment age of 12 years 1 month for females and 12 years 5 months for males. The PA and the JJ appliance were activated once in a month until Class II molar relationship was corrected to a super Class I molar relationship in both groups. Initial and final measurements and treatment changes were compared by means of Paired *t*-test. **Results:** Maxillary first molar distalized an average of 3.85 mm in the PA and 2.75 mm in the JJ between T1 and T2; rate of molar distalization was 1.59 mm/month for PA, and the JJ appliance averaged 0.88 mm/month, distal molar tipping was greater in PA (6.2°) than in the JJ (3.9°). Average mesial movement of the premolars was 2.2 mm with PA and JJ both. JJ showed a greater rotation of first molars after distalization as compared to PA. The increase in vertical facial height was also greater for JJ as compared to PA. **Conclusions:** Both the appliances were effective in molar distalization with PA requiring less distalization time (16 days less than JJ). Some adverse effects were noted with both which one should strive to control.

Key words: Distalization, jones jig, pendulum appliance

INTRODUCTION

Orthodontists have long sought methods to create space or to correct a dental Class II molar relationship without straining the lower arch and without the need for patient compliance. Over the past few years, nonextraction treatments with noncompliance therapies have become popular in treating Class II malocclusions.[1]

The pendulum appliance (PA) and the Jones jig (JJ) were introduced to orthodontics in the year 1992 by Jones and White[2] and Hilgers[3] respectively. PA is commonly used worldwide because of its ease in construction and cost-effectiveness. On the other hand, JJ commonly used in the United States is expensive but takes little chair side time for its installation and reactivation.

The PA and the JJ utilize the palate and premolars for anchorage. The PA delivers 200–250 g of force which is almost thrice the force delivered by JJ which

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is 70–75 g.[4] Both these appliances cause some distal tipping and rotation of the maxillary first molars during distalization. Few studies have investigated the dentoalveolar and skeletal postdistalization changes induced by the JJ[2,5,6] and the PA and reported varied results.[3,4,7-10]

There is a scarcity of literature about tandem comparison of PA and JJ appliance in orthodontic patients among Indian population. Considering wide use of these two appliances since the last decade, the study was aimed at assessing and comparing the clinical efficacy of these two commonly used molar distalization appliances in Indian orthodontic patients.

MATERIALS AND METHODS

The present study was conducted as postgraduate thesis program in reputed dental college, India after obtaining clearance from Institutional Ethical Committee. The sample size consisted of randomly selected 20 subjects (6 males, 14 females) between the age group of 9–13 years with an average age of 12 years 1 month for females and 12 years 5 months for males. The primary selection criterions were the absence of protrusive profile or mandibular retrusion, first molar relation either end on or a full cusp Angle Class II and horizontal or normal growth pattern (SN/Go-Gn angle <37°). Patients were divided into two groups, each group consisting of ten patients: Group A: Patients treated with the PA, Group B: Patients treated with the JJ appliances. The PA and the JJ appliance were activated once in a month until Class II molar relationship was corrected to a super Class I molar relationship in both groups. The appliances were then left in place for retention.

Pre- and post-distalization lateral cephalograms and study models were taken. The lateral cephalograms were taken from the right side, one before distalization, and the second immediately after distalization. All images were taken with the head in a natural head position, teeth in centric occlusion, and lips in repose. All cephalograms were hand-traced on orthodontic tracing paper on a conventional sight box using 0.3-mm lead pencil and were measured by the same investigator to avoid interoperator variations. A total of nine hard tissue landmarks and seven reference planes were used for different linear and angular measurements [Figures 1 and 2]. Three skeletal angular, one linear skeletal, three dental angular,

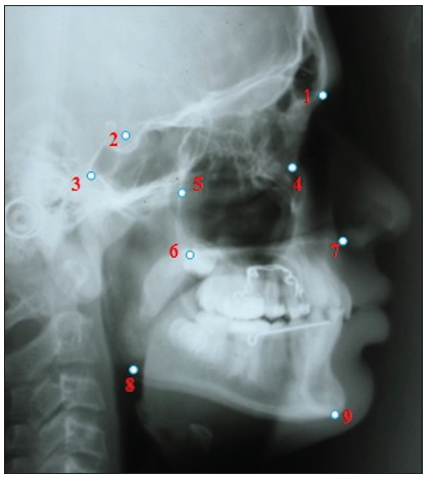

Figure 1: Cephalometric landmarks

and three linear dental measurements were measured on the cephalograms as illustrated. The parameters for the analysis of the lateral Cephalograms were taken from the study done by Ghosh and Nanda and Benedicto Ede *et al*.[4,7]

Linear and angular measurements used were as follows:

1. Skeletal angular measurements:
   - SN to palatal plane angle (SN-PP): The angle formed between SN line and the palatal plane
   - SN to occlusal plane angle (SN-OP): The angle formed between the SN and the occlusal plane
   - Frankfurt to mandibular plane angle (FMA): The angle formed between Frankfurt horizontal plane and mandibular plane.
2. Skeletal linear measurements:
   - ANS – Me: Vertical distance between anterior nasal spine and menton.
3. Dental angular measurements:
   - SN to Upper incisor (SN-MI): The angle formed between the anterior cranial base (SN) and the long axis of the upper central incisor
   - SN to upper premolar (SN-FPM): The angle formed between the anterior cranial base and the long axis of the premolar obtained by drawing a perpendicular to the midpoint of a line connecting the most convex point on its crown
   - SN to upper first molar (SN-FM): The angle formed between the anterior cranial base and the long axis of the upper first molar obtained by drawing a perpendicular to the midpoint of a line connecting the most convex point on its crown.
4. Dental linear measurements:
   - PTV to maxillary first premolar centroid (PTV-MAX FPM): The horizontal distance

between pterygoid vertical plane and the centroid of maxillary first premolar
- PTV to maxillary first molar centroid (PTV-MAX FM): The horizontal distance between pterygoid vertical plane and the centroid of maxillary first molar
- PTV to maxillary incisor tip (PTV-MAX INC): The horizontal distance between pterygoid vertical plane and the tip of the maxillary incisors.

Dental study model analysis

Impressions of the upper and lower arches before distalization and immediately after the distalization appliance was removed were taken. The dental casts obtained were analyzed as follows: The pairs of casts were marked with a black permanent marker representing the mesiobuccal cusp tip, distobuccal (db) cusp tip, central fossa (cf), and raphe-median line (RML) on the occlusal surface of the upper first molars as done by Kinzinger *et al*. in their study.[5] A single operator performed the analysis to avoid error due to interoperator variations. On both sides of each dental cast, measurements were taken of the distance from the lowest point in the cf to the mb and db cusp tips of the first molars. The linear measurements were done with a digital caliper. These measurements were done to identify for any increase or decrease in the transverse arch width in the first molar region following molar distalization. The angles between the straight line transversing the mb and db cusp tips and the RML were also measured which gave the magnitude and mode of molar rotation achieved by the appliances. The marked casts were scanned with UMAX Astra 3450 scanner. The scanned images were loaded onto the AutoCAD 2004 software, and the magnitude and mode of molar rotation were measured [Figures 3 and 4]. Statistical analysis was done using Statistical Package of Social Science (SPSS Version 20; Chicago Inc., USA). Statistical significance level was fixed at $P < 0.05$. The Student's *t*-test was used to analyze the variation in mean between two groups of a variable with a normal distribution.

RESULTS AND STATISTICS

Data were shown as mean ± standard deviation for continuous variables. The mean differences between pre- and post-distalization measurements were analyzed by paired Student's *t*-test to know whether there was any significant difference between the pre- and post-distalization means. Statistical significance was considered to be highly significant

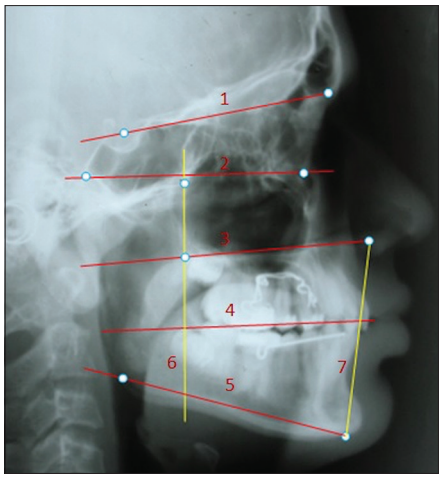

Figure 2: Reference planes

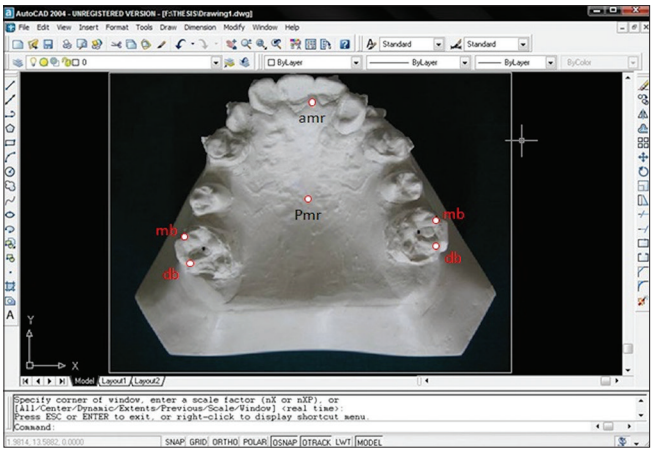

Figure 3: AutoCAD software with cast showing landmarks

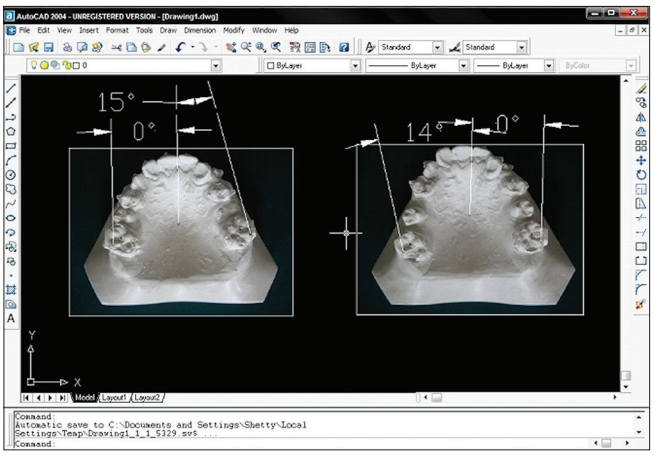

Figure 4: AutoCAD software with pre- and post-distalization casts measuring the rotation of the molars

at 0.1% ($P < 0.01$) level, significant at 5% ($P < 0.05$) level, and nonsignificant above 5% ($P > 0.05$) level.

The total amount of molar distalization averaged 3.85 mm in an average of 78.6 days for the PA group

with a highest of 6 mm and least of 3 mm. For the JJ group, the average distalization was 2.75 mm in an average of 94.7 days with highest of 4 mm and least of 2 mm. The rate of molar distalization was calculated as the amount of distalization per month. It was found that the PA distalized the molars at an average rate of 1.59 mm per month and the JJ averaged 0.88 mm per month [Tables 1 and 2].

There was a statistically significant ($P < 0.05$) increase in the transverse width between pre- and post-distalization of the left and right maxillary molars for the mb cusp tip (−2.525 + 2.5 mm), db cusp tip (−1.67 + 2.04 mm) and cf (−1.94 + 3.09 mm) for the PA group. In comparison with PA, a highly significant ($P < 0.001$) increase in the transverse width for the mb cusp tips (−1.492 + 0.94) and the cf (−1.171 + 0.843) was seen for the JJ appliance, but a nonsignificant ($P > 0.05$) decrease (0.0490 + 1.89 mm) was seen for the db cusp tips.

The PA demonstrated a statistically significant ($P < 0.05$) rotation of both the left (7.0000 + 8.11) and right maxillary first molars after distalization (7.7000 + 10.40), whereas the JJ appliance showed a highly significant ($P < 0.001$) rotation for both right (11.50 + 4.45) and left (13.6 + 4.90) first molars.

Both the appliances demonstrated a highly significant ($P < 0.001$) change in the angulation of the first maxillary molars after distalization. Comparison of the values between the pre- and post-molar distalization showed a decrease in the angulation suggesting a distal tipping type of movement of the maxillary first molars for both the appliances. The distal tipping was 6.2° for PA and 3.9° for JJ group.

Average mesial movement of the premolars was 2.2 mm and 3.1 mm for the incisors with PA. For JJ, the extent of mesial movement of the premolars averaged 2.2 mm, and for the incisors, it was 3.05 mm. The mesial movement of the anchorage units was same for both the PA and the JJ appliance.

Both the appliances showed an increase in the vertical facial height with the PA showing significant ($P < 0.05$) increase with respect to the SN-OP (−2.5 + 3.37) and FMA (−1.5 + 2.06) and very high significance ($P < 0.001$) with respect to ANS-Me. The JJ appliance showed a highly significant ($P < 0.001$) increase in the vertical facial height with regards to ANS-Me (−1.4 + 1.5).

The overall comparison of the cephalometric and the study model results suggested no statistically

Table 1: Pre- and post-distalization changes for pendulum appliance (results of paired *t*-test)

	Treat	Mean	SD	Mean different	SD different	Paired *t*-test	*P*	Significance
Transverse width of first molar								
mbct	Pre	49.4280	2.4098	−2.5250	2.5045	−3.1882	0.0110	S
	Post	51.9530	1.9201					
dbct	Pre	52.2100	2.0176	−1.6700	2.0437	−2.5840	0.0295	S
	Post	53.8800	2.0667					
cf	Pre	45.6800	2.0782	−1.9490	3.0997	−1.9883	0.0380	S
	Post	47.6290	2.5144					
Rotation of first molar								
Left	Pre	17.2000	4.7093	7.0000	8.1104	2.7293	0.0232	S
	Post	10.2000	6.1427					
Right	Pre	18.4000	11.8528	7.7000	10.4035	2.3405	0.0440	S
	Post	10.7000	12.9790					
Angular changes of first molar								
SN-FM	Pre	72.3000	4.4234	6.2000	4.0222	4.8745	0.0009	HS
	Post	66.1000	4.8865					
Changes in vertical facial height								
SN-PP	Pre	7.3000	2.5841	−1.3000	3.0203	−1.3611	0.2066	NS
	Post	8.6000	3.1340					
SN-OP	Pre	19.2000	3.3928	−2.5000	3.3747	−2.3426	0.0438	S
	Post	21.7000	3.5606					
FMA	Pre	27.8000	4.8944	−1.5000	2.0683	−2.2934	0.0475	S
	Post	29.3000	4.9900					
ANS-Me	Pre	66.3000	5.1865	−2.1000	1.3703	−4.8462	0.0019	HS
	Post	68.4000	4.5509					

HS at 0.1% ($P<0.01$) level, S at 5% ($P<0.05$) level and NS above 5% ($P>0.05$) level. SD: Standard deviation, HS: Highly significant, S: Significant, NS: Nonsignificant

Table 2: Pre- and post-distalization changes for Jones Jig appliance (results of paired *t*-test)

	Treat	Mean	SD	Mean different	SD different	Paired *t*-test	*P*	Significance
Transverse width of first molar								
mbct	Pre	50.4560	2.3598	−1.4920	0.9452	−4.9915	0.0007	HS
	Post	51.9480	2.0523					
dbct	Pre	53.5540	2.5372	0.0490	1.8907	0.0820	0.9365	NS
	Post	53.5050	2.2061					
cf	Pre	46.1820	1.9863	−1.1710	0.8433	−4.3910	0.0017	HS
	Post	47.3530	2.1622					
Rotation of first molar								
Left	Pre	19.3000	7.0875	13.6000	4.9035	8.7706	0.0000	HS
	Post	5.7000	6.9929					
Right	Pre	16.3000	7.5579	11.5000	4.4535	8.1658	0.0000	HS
	Post	4.8000	7.6710					
Angular changes of first molar								
SN-FM	Pre	75.9000	6.6908	3.9000	2.0248	6.0908	0.0002	HS
	Post	72.0000	6.8961					
Changes in vertical facial height								
SN-PP	Pre	9.0000	5.4772	−0.1000	3.3813	−0.0935	0.9275	NS
	Post	9.1000	3.7550					
SN-OP	Pre	16.8000	6.7297	−1.6000	3.7476	−1.3501	0.2100	NS
	Post	18.4000	6.2397					
FMA	Pre	24.2000	5.9777	−1.1000	2.8460	−1.2222	0.2527	NS
	Post	25.3000	6.7007					
ANS-Me	Pre	66.6000	9.7320	−1.4000	1.5055	−2.9406	0.0165	HS
	Post	68.0000	10.6354					

HS at 0.1% (P<0.01) level, S at 5% (P<0.05) level and NS above 5% (P>0.05) level. HS: Highly significant, S: Significant, NS: Nonsignificant, SD: Standard deviation

significant difference between the two appliances [Tables 3 and 4].

DISCUSSION

The present study compared compare two molar distalization devices, the PA and the JJ in dental Class II patients in Indian population among 20 patients. The result showed that both the appliances were effective in molar distalization (3.85 mm in the PA group and 2.75 mm in the JJ group), even if the PA required less distalization time (16 days less than JJ).

Comparison of the values between the pre- and post-molar distalization showed a decrease in the angulation of the first molar suggesting a distal tipping type of movement of the maxillary first molars for both the appliances. The result could be due to the point of force application was occlusal to the center of resistance. The PA showed more amount of tipping compared to the JJ appliance. The amount of distal tipping of the molars with a mean of 6.5°, which was statistically significant in our study, was found to be less when compared to the study by Ghosh and Nanda, which showed a mean distal tipping of 8.36°.[4] Kinzinger *et al*. reported a distal tipping of 3.29° which was way less when compared to our study.[5] Brickman *et al*. reported a distal tipping of 7.53°, which was more than seen in the present study samples.[11] The difference could be attributable to the difference in age groups and biomechanics.

The mesial movement of the anchorage units of premolars and incisors was same for both the PA and the JJ appliance. Mesial movement of the anchor unit was an unavoidable side effect that could occur with any conventional intraoral distalizing appliance. This finding was in accordance with the study by Ghosh and Nanda and Brickman *et al*.[4,11]

The JJ appliance showed a greater increase in the vertical facial height with regards to ANS-Me as compared to the PA. Similar results were obtained in the study by Patel *et al*.[12]

The comparison of pre- and post-distalization values indicated an increase in the transverse width between the first molars suggesting a buccal type of molar movement in the transverse plane for both the appliances. The molars distalized by the JJ appliance caused a more distopalatal rotation along with expansion in comparison to the PA which caused expansion with little rotation due to the rigid wire components attached palatally to the molars. The

Table 3: Comparison of cephalometric values between pendulum and Jones jig appliances (results of student's *t*-test)

Variable	Appliance	*n*	Mean	SD	*t*	*P*	Significance
Skeletal							
SN-PP	P	10	1.3000	3.0203	0.8370	0.4136	NS
	J	10	0.1000	3.3813			
SN-OP	P	10	2.5000	3.3747	0.5643	0.5795	NS
	J	10	1.6000	3.7476			
FMA	P	10	1.5000	2.0683	0.3595	0.7234	NS
	J	10	1.1000	2.8460			
ANS-Me	P	10	2.1000	1.3703	1.0873	0.2912	NS
	J	10	1.4000	1.5055			
Dental-angular							
SN-MI	P	10	3.5000	3.4721	0.0000	1.0000	NS
	J	10	3.5000	2.1731			
SN-FPM	P	10	5.7000	4.5959	1.8463	0.0814	NS
	J	10	2.9000	1.3703			
SN-FM	P	10	−6.5000	4.1966	−1.7645	0.0946	NS
	J	10	−3.9000	2.0248			
Dental-linear							
PTV-MAX INC	P	10	3.7000	1.8886	1.0842	0.2926	NS
	J	10	2.9000	1.3703			
PTV-MAX FPM	P	10	1.9000	1.1972	−0.3889	0.7019	NS
	J	10	2.1000	1.1005			
PTV-MAX FM	P	10	−2.7000	1.4944	−0.1917	0.8502	NS
	J	10	−2.6000	0.6992			

HS at 0.1% (*P*<0.01) level, S at 5% (*P*<0.05) level and NS above 5% (*P*>0.05) level. P: Pendulum, J: Jones jig, SD: Standard deviation, HS: Highly significant, S: Significant, NS: Nonsignificant

Table 4: Comparison of values of study models between pendulum and Jones jig appliances (results of student's *t*-test)

Variable	Appliance	*n*	Mean	SD	*t*	*P*	Significance
Mesiobuccal cusp tips	P	10	2.5250	2.5045	1.2203	0.2381	NS
	J	10	1.4920	0.9452			
Distobuccal cusp tips	P	10	1.6710	2.0423	1.9594	0.0657	NS
	J	10	−0.0540	1.8920			
Center of the fossa	P	10	1.9490	3.0997	0.7659	0.4537	NS
	J	10	1.1710	0.8433			
Rotation left	P	10	9.0000	6.9442	−0.5346	0.5995	NS
	J	10	10.7000	7.2732			
Rotation right	P	10	8.5000	9.6868	−0.0963	0.9244	NS
	J	10	8.9000	8.8751			

HS at 0.1% (*P*<0.01) level, S at 5% (*P*<0.05) level and NS above 5% (*P*>0.05) level. P: Pendulum, J: Jones jig, SD: Standard deviation, HS: Highly significant, S: Significant, NS: Nonsignificant

JJ appliance demonstrated the rotation of the molar more than that of the PA probably because the JJ appliance applied the distalizing force from the buccal side with no restriction from the palatal aspect unlike the PA, which connects to the molars from the palatal aspect through rigid wire components. Same have been reported by Schütze *et al*.[13]

The limitations of the study were its limited sample size, the need for a long-term follow-up to evaluate the changes after the completion of orthodontic treatment and more advanced aids like cone beam computed tomography could be used to evaluate the changes.

CONCLUSIONS

The PA and the JJ appliance can be efficiently used for the distalization of the maxillary first molars from a Class II or an end on molar relationship to a full cusp Class I relationship without the need for patient compliance in Indian population. Both these appliances caused relative loss of anchorage resulting

in an increase in the overjet. As with most of the distalizing appliances, the pendulum and JJ appliance should be monitored cautiously for the loss anchorage resulting in the increase in overjet. The patients should be advised to report immediately if the ligature wire that activates the coil spring in the JJ appliance breaks or comes loose, which commonly happens, which otherwise might lead to relapse thereby increasing the treatment time.

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Conflicts of interest
There are no conflicts of interest.

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