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Volumetric pulpal changes in permanent first molars following AdvanSyncTM and Twin Block functional appliance: A CBCT study

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Abstract

INTRODUCTION: Dental pulp may respond differently to adverse orthodontic forces. Major physiological effects of optimum orthodontic force application on dental pulp are vascular pulpal changes, pulpal calcification, and fibrosis. Functional appliances taking anchorage from the dentition tend to exert reciprocal higher orthodontic forces.

OBJECTIVE: To evaluate the 3D volumetric changes of the dental coronal pulp of maxillary and mandibular permanent first molars 6 months after AdvanSync™ fixed functional and Twin Block removable functional appliance therapy and followed at 18 months of treatment (T2).

MATERIALS AND METHODS: This retrospective study was performed on CBCT records obtained from a previous prospective study (Randomized Clinical Trial) comprising 32 patients [females: 17 (9.0–14.5 years), males: 15 (10.5–15.0 years)] who underwent functional mandibular advancement with Twin Block (group 1) and AdvanSync™ (group 2). Pretreatment (T0), 6 months (T1), and 18 months (T2) follow-up CBCT were assessed for dental pulp volume by using ITK-SNAP software version 3.2.

RESULTS: Intragroup volumetric pulpal changes showed a significant decrease in #16, #26, and #36 at time intervals T0–T1, T0–T2, and T1–T2 in groups 1 and 2. Intergroup comparison of pulpal volume for #16 and #26 was statistically significant at T1. A statistically significant decrease in pulpal volume for #46 was observed at time intervals T0–T1, T0–T2, and T1–T2 in both groups.

CONCLUSION: Functional appliance therapy with both Twin Block and AdvanSync™ functional appliance tends to decrease the first molar pulpal volume.

Keywords:

AdvanSync, CBCT, functional appliance, pulp response, Twin Block

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Introduction

Dental pulp is the neurovascular bundle inside the tooth that maintains the vitality of the teeth. Dental pulp may respond in different manners to adverse orthodontic forces. Major physiological effects of optimum orthodontic force application on dental pulp are vascular pulpal changes, pulpal calcification, and fibrosis.[1-6] The long-term application of orthodontic forces (such as intrusion and extrusion) may jeopardize pulp vitality.[7] Lazzaretti *et al*.[8] found that intrusive orthodontic forces caused vascular changes in the pulpal tissue and increased the presence of fibrosis and the number of pulp calcifications. The maxillary posterior teeth showed significant volume and shape changes following maxillary expansion.[9,10] Mustafa Hussein

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Alattas (2023)[11] showed that orthodontic forces were associated with increased blood flow, reduction in pulpal volume, increased CGRP expression, and inflammation.

The major objective of interceptive orthodontic treatment in growing patients with skeletal and dental class II malocclusion is to achieve early skeletal correction with minimal side effects. Removable functional appliances such as Twin Block Functional Appliance (TBFA) and fixed functional appliances AdvanSync™ Functional Appliance (ASFA) are commonly used for the management of growing patients with skeletal class II malocclusion due to mandibular retrusion. Twin Block appliance takes anchorage from the dentoalveolar, palatal, and lingual sulcus area, and ASFA takes anchorage from maxillary and mandibular permanent first molars. These appliances hold the mandible in an anterior position, taking anchorage from teeth, thus reciprocal forces are expected to act on these teeth. The level of the forces in these appliances is higher than the orthodontic forces.

The use of three-dimensional (3D) diagnostic tools such as cone beam computed tomography (CBCT) is increasing in orthodontics because of the development of low-dose 3D imaging techniques and recent software to manipulate them.[12] Previous studies have shown good reliability in evaluating the pulpal volume by using CBCT.[4,13-15] Hatrom AA *et al*.[13] evaluated pulp volume changes in anterior teeth after precision-assisted tooth movement and found a decrease in pulpal volume after fixed orthodontic treatment. Venkatesh *et al*. (2014),[4] Abdel-Kader and Ammar (2015),[14] and Baratieri *et al*. (2013)[15] evaluated pulpal changes after canine retraction, en-masse retraction, and RME on CBCT, but the effect of heavy forces by fixed functional appliances and removable functional appliances on the dentin-pulp complex is yet unclear. There is a high possibility of adaptive changes in the coronal pulp tissues of the first permanent molars in both arches due to excessive intrusive and mesiodistal forces. Therefore, the current research was planned to compare the effect of removable functional (Twin Block) and fixed functional (AdvanSync) appliances on the 3D volume of the dental coronal pulp in maxillary and mandibular first permanent molars.

Objective

To evaluate the 3D volumetric changes in the dental coronal pulp of maxillary and mandibular permanent first molars 6 months after AdvanSync™ fixed functional and Twin Block removable functional appliance therapy and followed at 18 months of treatment (T2).

Material and Methods

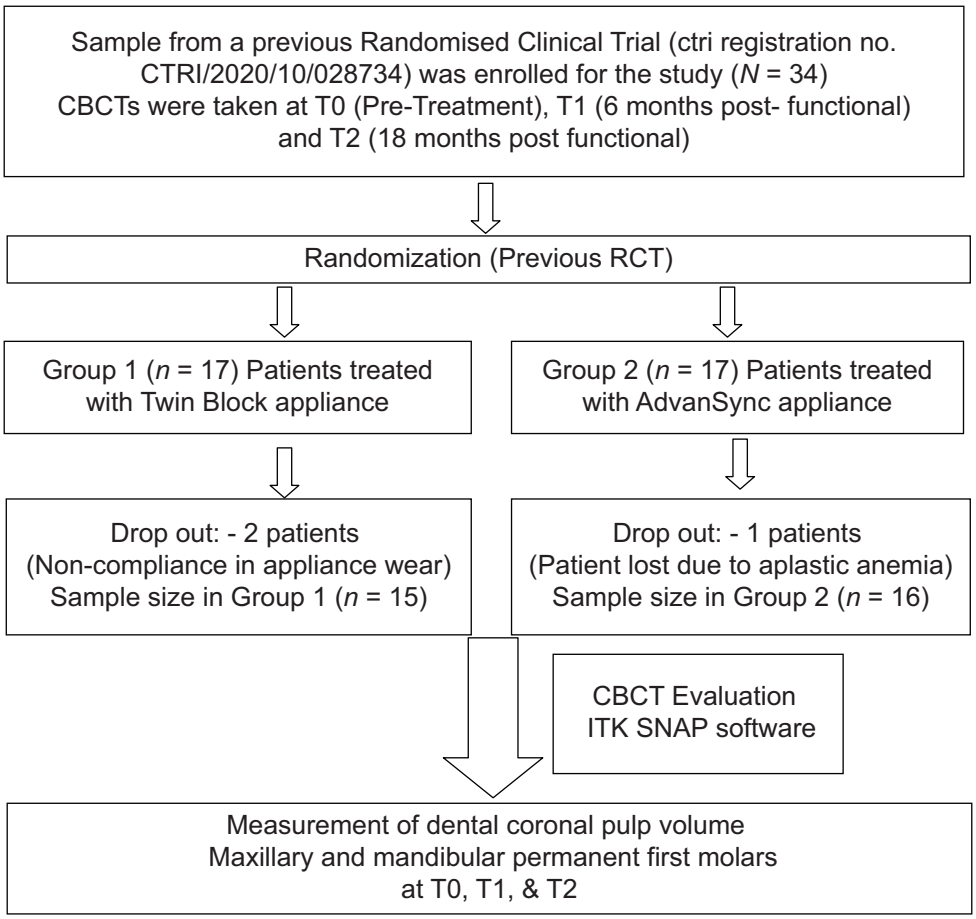
This retrospective study was conducted after ethical clearance from the institutional ethics committee (INT/IEC/2022/SPL-1594). The CBCTs of patients obtained from a previous randomized Clinical Trial (CTRI registration no. CTRI/2020/10/028734) conducted in the department were evaluated at T0 (Pre-Treatment), T1 (6 months post- functional) and T2 (18 months). The sample consisted of patients with skeletal class II malocclusion, with ANB angle >5°, class II molar relationship, minimum overjet of 7 mm, and growth status in cervical vertebrae maturation stages 3 and 4. Patients with craniofacial syndromes, enlarged adenoids or nasal obstructions, and Frankfort mandibular plane angle of >28° were excluded. The study consisted of two groups according to the type of intervention. Patients in group 1 and group 2 were treated with Twin Block and AdvanSync, respectively.

In group 1, the interception of mandibular deficiency was done using standard Twin Block appliances.[16] After 1 week, children were instructed to wear the appliance 24 hours a day. Inter-occlusal acrylic trimming was performed to allow unhindered vertical development of the mandibular buccal segments. When necessary, compensatory lateral expansion of the maxillary arch was achieved with a maxillary expansion screw. In group 2, for AdvanSync appliance in patients after crown-size selection, the crowns were cemented on lower crowns and then the upper crowns with pre-attached mechanism were cemented on both sides. The telescope was aligned with the mesial casing of the lower crown; before fixing it, C spacers were used for further activation. In both groups, class II corrections were maintained by class II elastics with fixed appliances.

All CBCTs were taken with the same equipment and with similar equipment settings using Kodak 9500 C (Care-stream Health Inc. Onex Corporation, Toronto, Canada) with a standard protocol of exposure of 90 kV,10 mA, 14.20 s, and voxel size of 200 µm × 200 µm × 200 µm (with a slice thickness of 0.2 mm). Patients were followed up for a further 18 months (T2) and stage records including CBCT were taken at 0, 6, and 18 months. Flowchart 1 depicts the overview of the methodology of the study.

Assessment of dental pulp volume

The CBCTs of patients included in previous RCTs were evaluated by a single examiner. Pulpal volume was assessed at different time intervals by using ITK-SNAP software version 3.2.[17,18] CBCT volumes of patients were imported in ITK SNAP software. The area of interest was selected by placing the cursor on the first molars. Coronal dental pulp was marked, and a 3D STL file of pulpal volume was calculated after its 3D replica was created by paintbrush mode with the optimal size of the paintbrush. Preferences were selected at two standard deviations, and featured edge smoothening was selected in the rendering tool.[19]



Flowchart 1: Overview of the methodology of the study

The investigator was calibrated to set threshold values and segment pulp volume from CBCT. The intraexaminer reliability was assessed by repeating the measurement of selected parameters on 10% of all the CBCTs selected randomly after an interval of three weeks. The value of intra-class correlation (ICC) ranged from 0.989 to 0.999, which indicated excellent reliability between 1st and 2nd measurements.

Statistical analysis

One-Sample Kolmogorov-Smirnov test was used to check the distribution of the sample. The distribution was non-normal for #16, #26, and #36. Hence, non-parametric tests Mann-Whitney test and Wilcoxon signed ranks test were used to compare the changes for #16, #26, and #36. Intragroup comparisons at time intervals T0, T1, and T2 for #46 among groups 1 and 2 were done using repeated ANOVA and pairwise comparison (multiple comparison Bonferroni), and t-test was used for intergroup comparisons.

Results

Table 1 shows the gender and age distribution of the sample among groups 1 and 2. The mean ages of groups 1 and 2 were 12.23 ± 1.64 and 13.00 ± 1.62, respectively, and the differences were statistically non-significant. Intragroup volumetric pulpal changes showed a significant decrease in #16, #26, and #36 at time intervals T0–T1, T0–T2, and T1–T2 in groups 1 and 2 [Table 2]. Intergroup comparison of pulpal volume showed no significant differences at T0 and T2 for #16, #26, and #36. Intergroup comparison of pulpal volume for #16 and #26 was statistically significant at T1 but was statistically non-significant for #36. Table 3 shows a statistically significant decrease in pulpal volume for #46 at time intervals T0–T1, T0–T2, and T1–T2 in groups 1 and 2. Intergroup comparison of pulpal volume for #46 was statistically non-significant at time intervals T0, T1, and T2.

Discussion

The different methods used to assess the pulpal changes included laser Doppler flowmetry, radiographs (IOPA and OPG) to detect pulpal fibrosis and pulp stones, electric pulp testing (EPT) values, CGRP expression, and CBCT scans.[20] The most common orthodontic tooth movements evaluated were intrusion, extrusion, and rapid maxillary expansion. In this study, the

pulpal changes following the management of growing skeletal class II patients with functional appliances were evaluated using CBCT scans that were available from a clinical trial previously conducted in the department. Several studies evaluated pulp stone formation and pulpal calcification following conventional orthodontic treatment using periapical and OPG radiographs and showed a slight increase in pulpal stones (2%–6%).[21-25] The changes in two-dimensional radiographs may not be very reliable.

Both AdvancSync and Twin block are indicated for correcting skeletal class II due to mandibular retrusion in growing subjects. and is clinically similar except for the advantage of AdvancSync for non-compliant patients. Thus, the two appliances are compared for their adverse effects to improve their clinical usage. The present study using CBCT showed a reduction in pulpal volume in both groups. The changes were significant at a follow-up of both 6 months and 18 months. This may be because of the heavy forces applied to the teeth during functional appliance therapy that led to pulpal distress and inflammation and reduction in pulpal volume due to tertiary dentine formation, fibrosis, and pulp stone formation, all being protective mechanisms following pulpal trauma. Previous studies by Venkatesh *et al*. (2014)[4], Abdel-Kader and Ammar (2015)[14], and Baratieri *et al*. (2013)[15] evaluated pulpal changes after en-masse retraction, canine retraction, and RME by using CBCT also showed adverse changes after the application of orthodontic forces. Venkatesh *et al*. (2014)[4] showed reduced pulp cavity dimensions in all anterior teeth, with the highest in lateral incisors. Canine retraction did not change the pulp chamber dimensions. After RME, no differences were seen in molars. Mustafa Hussein Alattas (2023)[11] showed that orthodontic forces were associated with increased blood flow, reduction in pulpal volume, increased CGRP expression, and inflammation.

The intergroup comparison between the effect of two functional appliances on pulpal response showed a mixed response. The changes in the pulpal volume of #36 and #46 at T1 and T2 were non-significant between the two groups. The pulpal volume of #16 and #26 observed at T1 was significantly less for group 2. This included the forces due to functional appliances followed by orthodontic forces. The time interval of 6–18 months mainly consisted of fixed orthodontic

Table 1: Age and gender-wise distribution

Interventional Groups	Sample size		Total Sample	Age (years)	Range
	Male	Female		Mean±SD	
Group 1	10	5	15	12.23±1.64	9.0–14.5
Group 2	12	5	17	13.00±1.62	10.5–15.0
P				0.257	

Group 1: Twin Block; Group 2: AdvanSync™. The mean difference is significant at *P*=0.05

Table 2: Inter and intragroup volumetric pulpal changes in #16, #26, and #36 among groups 1 and 2 at different time intervals

	Volume at T0	Volume at T1	Volume at T2	T0–T1 *P*	T0–T2 *P*	T1–T2 *P*
16						
Group 1	60.31±3.90	57.52±3.59	53.05±3.24	0.001	0.001	0.001
Group 2	60.70±4.05	54.99±4.52	49.98±5.64	0.001	0.001	0.001
Gp 1vs Gp 2 (*P*)	0.791	0.043	0.144			
26						
Group 1	59.09±4.68	56.48±5.04	50.44±6.50	0.001	0.001	0.001
Group 2	58.97±4.32	53.48±3.89	47.37±4.11	0.001	0.001	0.001
Gp 1vs Gp 2 (*P*)	0.880	0.043	0.144			
36						
Group 1	42.14±5.39	39.75±5.18	35.26±5.37	0.001	0.001	0.001
Group 2	43.68±4.72	37.93±3.61	34.10±3.13	0.001	0.001	0.001
Gp 1vs Gp 2 (*P*)	0.336	0.336	0.580			

Group 1: Twin Block; Group 2: AdvanSync™. T0: Pretreatment; T1: 6 months follow-up; T2: 18 months follow-up

Table 3: Inter and intragroup volumetric pulpal changes in #46 among groups 1 and 2 at different time intervals

	Repeated ANOVA *P*	Pairwise comparison (multiple comparison Bonferroni) at different time intervals								
		T0–T1			T0–T2			T1–T2		
		Mean Diff	*P*	CI	Mean Diff	*P*	CI	Mean Diff	*P*	CI
Group 1	0.000	2.50	<0.001	2.02–2.98	7.66	<0.001	5.09–10.22	5.15	<0.001	2.76–7.54
Group 2	0.000	4.50	<0.001	3.02–5.98	8.71	<0.001	6.44–10.97	4.21	<0.001	3.08–5.33
Gp 1 vs. Gp 2 (*t*-test)			0.212			0.837			0.366	

Group 1: Twin Block; Group 2: AdvanSync™. T0: Pretreatment; T1: 6 months follow-up; T2: 18 months follow-up. Mean difference is significant at *P*=0.05

forces. There are signs that AdvanSync may affect the pulp more adversely at 6 months than Twin Block because of the direct forces on the teeth by the appliance. However, as there were no differences at 18 months of follow-up, no long-term increased insult on pulpal health by AdvanSync compared to Twin Block was observed.

Clinical implication

The present study's findings suggest that AdvancSync, a fixed functional appliance, causes more pulpal changes on short-term follow-up (6 months). Thus, removable functional appliances should be preferred wherever possible to limit pulpal damage. The use of the AdvancSync appliance should be limited to non-compliant patients. As there were no differences at 18 months of follow-up, no long-term increased insult on pulpal health by Advancsync compared to twin block was observed.

None of the molar teeth in the sample observed showed any adverse clinical findings indicating root canal treatment.[20] However, teeth history of trauma is more likely affected by orthodontic forces and thus should be taken into consideration while planning treatment.

Limitation

Though the CBCT was taken from a previous RCT, it was a retrospective study. A meticulously designed RCT to analyze pulpal volume changes on a bigger sample may be more conclusive.

Conclusion

It may be concluded from the study that there is a decrease in the pulpal volume of molar teeth after functional appliance therapy with both Twin Block and AdvanSync functional appliances. There were differences in the long-term effects of the two appliances on the pulpal volume.

Ethics approval and consent to participate

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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