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EFFECTS OF CLASS II TREATMENT WITH HYBRID FIXED FUNCTIONAL APPLIANCES ON ROOT LENGTH AND ROOT VOLUME– A PROSPECTIVE STUDY USING CBCT

Orthodontology

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ABSTRACT

AIMS AND OBJECTIVES: The aim of this study was to evaluate and compare the root length and root volume changes in maxillary first molars and mandibular anterior teeth (Anchor teeth) using CBCT in Class II division 1 patients treated with Powerscope and Forsus appliances.

MATERIALS AND METHOD: The study sample comprised of Twenty patients, (mean age of 14.74±2.13years) with Class II divison 1 malocclusion were randomly divided into two groups with 10 patients in each group. Group I was treated with Powerscope appliance and Group II was treated with Forsus fatigue resistant device. CBCT records were obtained before the placement and at the time of removal of the appliances. all the anchor teeth were evaluated for root length and volumetric changes by using xelis dental CBCT software (Dental3D version 1.0.5.0 BN4).

RESULTS: All anchor teeth showed statistically significant decrease in the root length and volume in both the groups (P=0.001). But the decrease in the root length of mandibular canines and mandibular right lateral incisor root volume was statistically more significant in Powerscope group than the Forsus group. (P=0.02 & 0.029 respectively)

CONCLUSION: Significant amount of root length and volume changes were evident in all the maxillary first molars and mandibular anteriors in both the groups. But powerscope appliance resulted in significantly more root length and volumetric resorption than in Forsus appliance.

KEYWORDS

Powerscope, Forsus FRD, hybrid fixed functional, root resorption

Root resorption is one of the most common adverse effects of orthodontic treatment with being fixed functional appliances of no exception. Fixed functional appliances are known to be associated with exertion of heavy orthodontic force on mandibular anterior and maxillary posterior teeth which serve as an anchor unit. This deleterious effect causes apical root resorption, an undesired sequel of active orthodontic treatment.[1]

The first fixed functional appliance was introduced by Emil Herbst in 1905 but it gained popularity only after 1979, as documented by Pancherz[2]. The Herbst appliance being a rigid functional appliacne has certain disadvantages, such as restriction of lateral mandibular movement, difficulty in oral hygiene maintenance and breakage of the appliance[3]. In a clinical study with Herbst appliance, Nasiopoulos AT et al (2006)[4] demonstrated a statistically significant decrease in the root surfaces of the mandibular first premolars, which were used as the anchorage teeth for the fixed functional appliance.

So to rule out the disadvantages of the rigid and flexible fixed functional appliances, hybrid fixed appliances were introduced. The Forsus ™ Fatigue Resistant Device (3M Unitek corp, USA) was introduced in 2001 by William Vogt[5] which is a semirigid fixed functional appliance that is claimed to be delivering consistent forces.[5-7] Powerscope (American orthodontics, USA) is also a semirigid one piece, one size- fit all hybrid fixed appliance introduced in 2014 by Andy Hayes[8] which is advocated by him to be simple in design, hygienic, and requires less inventory delivering consistent forces than the other fixed functional appliances.[9,10]

The diagnostic value of OPG/IOPAs to assess root resorption is limited as they provide 2-dimensional (2D) images of complex 3-dimensional (3D) anatomic structures.[11]. 3D imaging such as Cone Beam Computed tomography (CBCT) has been used to visualize apical root resorption and is a useful source to provide an accurate diagnosis of the extension and location of the resorption.[11,12]

There is a lack of three dimensional comparison studies available on hybrid fixed functional appliances, investigating the root length and volumetric resorption on maxillary first molars and mandibular anteriors. So this present study was done to compare the apical root resorption in patients treated with Powerscope appliance and Forsus Fatigue Resistant Device.

MATERIALS AND METHOD

The study was conducted on 20 skeletal Class II patients, in the age group of 12-17 years (mean age=14.74±2.13years). The subjects were randomly allocated for treatment of two groups by using a restricted random number table to ensure equivalence of numbers in each group. The groups were as follows: (Table 1, 2)

- Group I- 10 patients treated with Powerscope appliance
- Group II- 10 patients treated with Forsus appliance

Inclusion criteria for the patients in study was:-

- Patients with skeletal Class II malocclusion, requiring skeletal mandibular sagittal correction with growth period at or before the CVMI maturation stage 5.
- Molar relation with a minimum of half the cusp width of Class II molar relationship
- Increased overjet, not less than 5mm
- SN/Go-Gn angle $\leq 32^0$
- Positive clinical Visual treatment objective (VTO)
- No history of any systemic medical illness

Exclusion criteria for the patients in study was:-

- Pretreatment signs and symptoms of temporomandibular joint dysfunction.
- Cases having condylar resorption.
- Incompletely formed roots or any sign of root resorption.

After selection, patients were treated with 0.022" MBT pre-adjusted edgewise appliance using consistent contemporary biomechanic principles. Both maxillary and mandibular arch wires (0.019"X0.025"SS) were left in place for 6 weeks for complete leveling and aligning. A labial root torque of 10^0 in the mandibular anterior region was added so that minimum proclination of the mandibular incisors takes place and wire was cinched distal to the molar tube.

Powerscope appliance (Fig 1) was installed intraorally by securing the maxillary and mandibular arch wires to the wire attaching nuts in the appliance with the help of hex driver. (Fig 2) In maxillary arch the appliance was fixed mesial to the first molar and in mandibular arch it was fixed distal to the canine on the archwires. Activation of the appliance was done by the addition of shims on the pushing rod till it covers the activation black dot on the appliance. The patient was

recalled every month for check-up and additional shims were added according to the requirements.

Since Forsus Fatigue Resistant device size for each patient was selected by measuring intraorally using the 3M gauge provided with the Forsus appliance. (Fig 3,4) Forsus FRD spring was secured in maxillary first molar head gear molar tube and distal to mandibular canine in the arch wire. Both the appliances were maintained in place for 6 months.

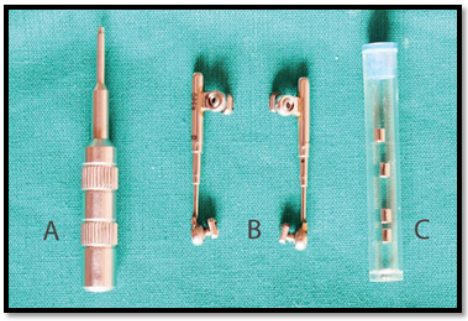


Fig.1 Figure showing Powerscope appliance with its components (A) Hex driver, (B) Right and left side Powerscope appliance © Shims

Fig.2 Powerscope installation in patient

Fig.3 Forsus fatigue resistant device with different sizes

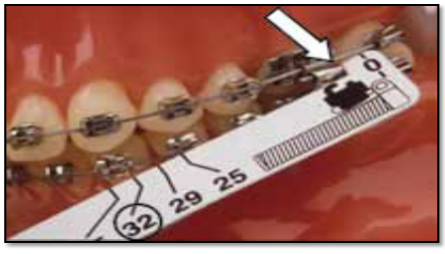


Fig.4 Size selection using 3M gauge intraorally

CBCT Records were collected at two intervals of time;
T0: At the time of placement of appliance
T1: At the removal stage of appliance

ROOT LENGTH AND VOLUME EVALUATION PROCEDURE

The CBCT scans were evaluated by Xelis dental software (Dental3D version 1.0.5.0 BN4). The scans were coordinated in all the three planes along the long axis of the tooth i.e. coronal, sagittal and axial plane to minimize any error. (Fig.5) Before taking the measurements brightness and contrast were adjusted accordingly. Since the changes in the root length and volume were calculated at placement and removal of the fixed functional appliances, the rooth length and volume changes caused by fixed orthodontic appliance was excluded.

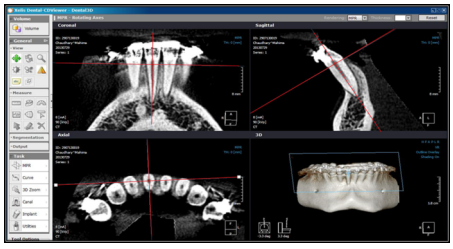


Fig.5 Co-ordination of scans in all three planes for standardization

- **ROOT LENGTH**

For maxillary first molars root length was calculated from the furcation point to the root's most apical point individually in all the three roots and for the mandibular anteriors, it was measured from cementoenamel junction to the root's most apical point in the sagittal section of the roots, using the measure tool[11,12] available in Xelis dental software (Fig 6). Measurement of root length changes (linear root resorption) was calculated by difference between the root length at placement of fixed functional appliance and after removal of the same appliance.[11,12]

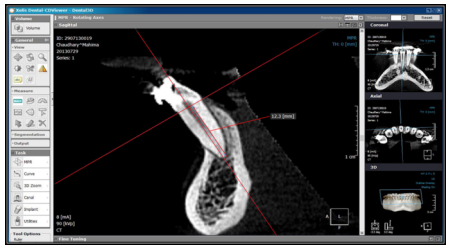
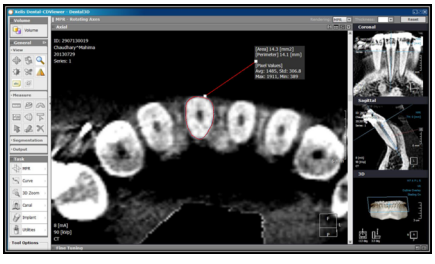
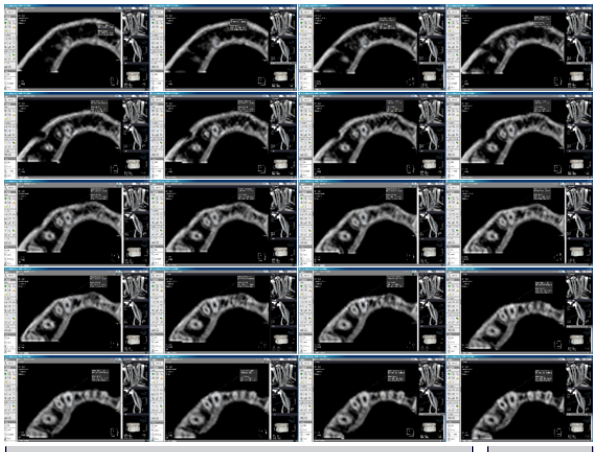


Fig.6 Linear measurement (Length of tooth in sagittal section from CEJ to root apex)

- **ROOT VOLUME**

For maxillary first molars root area in each slice was measured from the furcation point to the root's most apical point and for the mandibular anteriors it was measured from cementoenamel junction to the root's most apical point using area calculation tool which is available in Xelis dental software. (Fig 7,8) The volume of root in each slice was calculated by multiplying the root area by the slice thickness (i.e. 0.3 mm). Total volume of the root was calculated by adding the volume of each slice thickness.12 Measurement of root volume changes (volumetric root resorption) was also calculated as before by difference between the root volume at placement of fixed functional appliance and after removal of the same appliance.





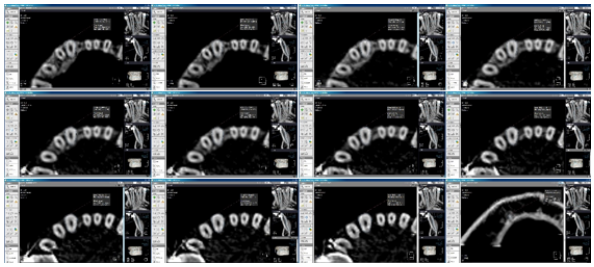


Fig.8 Measurement of area of axial slices from CEJ to root apex

STATISTICALANALYSIS

The software used for the statistical analysis was **SPSS (Statistical Package for Social Sciences) version 16.0 and Epi-info version 3.0**. The statistical tests used were **Unpaired or independent samples t-test** for comparison of mean value of 2 groups when data follows the normal distribution, **Mann-Whitney U test** was used for comparison of mean value between 2 groups and **Wilcoxon sign rank test** was used for comparison of 2 mean values obtained from a same group when data does not follows the normal distribution. The correlation between the 2 variables was calculated using the **Pearson's correlation coefficient (r).** To check the intra operative error three patients from each group were randomly selected and the measurements were done again after 15 days. The range of error according to the Dahlberg's formula in root length and volume assessment was 0.217 to 0.364 in Group I and 0.103 to 0.384 in Group II which was statistically insignificant.

RESULTS

The mean of root length changes (linear root resorption) and root volume changes (volumetric root resorption) for individual tooth were calculated and comparisons were made on these parameters both within the groups (intragroup) and in between the groups (intergroup) using statistical formulae and values were tabulated. (Table 3, Table 4)

Root length and volume changes assessment for linear and volumetric root resorption

- **Maxillary First molars**

The measurements for mesio buccal (MB) roots, disto buccal roots (DB) and palatal roots of 16&26 showed that there was a statistically highly significant decrease in root length and volume from T0 to T1. (p-value=0.001) (Table 3,4)

- **Mandiular anteriors**

All the mandibular anterior teeth (incisors and canines) showed statistically very highly significant decrease in the root length and volume from T0 to T1 (p-value = 0.001) (Table 3,4)

According to Pearson's correlation coefficient, the correlation between pre and post measurements in Group I was more than 0.8 which was statistically significant having correlation between the two measurements. (Table 3,4)

Comparison between Group I and Group II for root length and volume changes

On intergroup comparison, the difference in the root length from T0 and T1 (linear root resorption) was significant in relation to 33 and 43 in Group I than Group II with p-values 0.025 and 0.002 respectively. On the otherhand intergroup comparison on the basis of root volume changes, there was statistically significant decrease in root volume from T0 and T1 in relation to 42 in Group I than Group II with the p-value of 0. 029. However, other than these three teeth, the decrease in the root length and volume were similar between both the groups and the difference between the groups were statistically insignificant. (Table 3,4)

Discussion

One of the commonly used fixed functional appliances in recent treatment modalities for Class II malocclusion correction is the Forsus Fatigue Resistant Device (FRD) [13]. Since the Forsus appliance is provided with the open coil spring assembly, it leads to the lodgement of food particles which needs regular monitoring of the oral hygiene. This disadvantage was overcome by a new hyrid fixed functional appliance known as Powerscope appliance which is a direct modification of Herbst Type II appliance. The Powerscope is fixed directly onto the archwire eliminating the necessity of bands and headgear tubes thus minimizing the inventories.[8] So, Powerscope can be a better substitute for the Forsus appliance for effective treatment of Class II malocclusions.

Root resorption is one of the unpredictable and irreversible adverse effects of orthodontic treatment. Its causes are unclear, but systemic, genetic, and treatment-related factors are mainly predicted to be involved[14]. Nasiopoulos A (1992) stated that the occlusal changes produced by the fixed functional appliances may lead to exposure of patient's teeth to a highly complex force system due to alteration in the oral musculature and soft tissue[1]. These forces strength and duration vary according to the function of the oral cavity. If these sustained forces are too strong or last too long, there is always a possibility of resorption in the apical area or an inhibiting effect on the root development if root growth is incomplete.[14-19]

In some studies[1, 20], intraoral periapical radiographs were used for the determination of orhodontically induced apical inflammatory root resorption (OIARR). Even with efforts to obtain periodically identical radiographs, this technique has shortcomings and also, intraoral radiographs do not indicate the true dimensions of lesions.[1, 20] Hence, 3D imaging techniques have the potential to offer accurate quantification of root resorption defects and, perhaps, earlier detection of lesions.[21] Conventional computed tomography (CT) has been shown to have high sensitivity and specificity in the detection of external root resorption defects in vitro. High cost and radiation exposure make this modality generally unsuitable for routine imaging of the dentition.[22] Cone-beam CT (CBCT) is an imaging modality that offers the advantages of 3D voxels and high diagnostic yield with short scanning times and significantly lower radiation dosages than conventional CT.[23] Therefore this study was undertaken to evaluate and compare the effects of two hyrid fixed functional appliances treatment on root length and volume of the anchorage teeth with the use of CBCT.

According to result of this study, both Powerscope and Forsus appliances lead to statistically significant amount of linear and volumetric root resorption in all the anchor teeth. These results were in concordance with the studies done by Nasiopoulos AT et al[4] and Kinzinger GSM[1] on fixed functional appliances, demonstrating a statistically significant decrease in the root surfaces of the anchorage teeth.

Similarly in a three dimensional study (CBCT) done by Schwartz JP[24], an association was found between Herbst appliance and orthodontically induced inflammatory root resorption in the anchoring teeth but it was clinically insignificant which were contrast to our study results.

Since both the appliacnes used in the study delivered around 200-250gms of force on the anchor teeth, heavy forces may be considered as on the reasons for the root resorption in those teeth. These results were in agreement with the study results of Chan E and Darendeliler MA (2006)[25] and Weltman D[26] denoting that heavy forces under the range of 200-250gms make the teeth more susceptible to root resorption than the lighter forces.

Another reason which can be suspected for the root resorption in all these is the duration and mode of action of force which is continuous in the fixed functional appliances. Acar A et al(1999)[27] advocated that continuous force produced significantly more root resorption than interrupted force application which is similar to the present study results that showing tendency for root resorption (both linear and volumetric) in the teeth under continuous forces.

In our present study, result showed that there was significantly more amount of root root resorption in mandibular anteriors in Powerscope group (Group I) than the Forsus group (Group II). It can be explained by an assumed fact that, Powerscope appliance is secured to the arch wires which leads restricted sliding movement of the appliance in mandibular archwire thereby moreorless fixing the point of application of force, from where force is transmitted to the mandibular anteriors teeth along the arch wire. So it produces a strong intrusive and horizontal force vectors nearer to the canine teeth on both the sides from the point where it is fixed in the archwire which is not so in the Forsus group since pushrods in the Forsus appliance are not rigidly fixed at a single point. Therefore, forces acting on mandibular anteriors would have been more in Group I than the Group II leading to significantly more root resorption in the mandibular canine teeth followed by mandibular lateral incisors.

Thus, our present study results showed that there was significantly more amount of reduction in root length in mandibular right and left canines, and also root volume in relation to mandibular right lateral incisor in Group I than Group II. Volumetric root resorption in mandibular lateral incisor can also be explained by a fact that the root surface area of mandibular incisors are less than that of other teeth, thus forces transmitted to the mandibular incisors would have increased susceptibility for root resorption than other teeth. In those mandibular incisors, mandibular lateral incisor was affected rather than central incisor due to the fact that force gets dissipated as it passes towards the mandibular central incisors.

CONCLUSIONS

- Both the hyrbrid fixed functional appliance resulted in significant amount of linear and volumetric root resorption in all the anchorage teeth studied.
- On comparison between both the groups, significantly more root length and volume resorption (decrease) was found in mandibular anteriors with Powerscope appliance than the Forsus appliance.

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