RESEARCH PAPER

Comparative Evaluation of Root Resorption of Maxillary Central Incisors with Conventional and Self-Ligating Brackets - A Cbct Study

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INTRODUCTION

External apical root resorption (EARR) is defined as either a physiologic or pathologic process with the loss of cementum or dentine resulting in a shortening of the root apex.[1] It is an undesirable sequel of orthodontic treatment that results in permanent loss of tooth structure from the root apex.[2] External root resorption was first described by Bates in 1856 in a paper titled "Absorption", and later in 1914, Ottolengui related this damage to orthodontic treatments.[3] Ketcham was among the first to seriously investigate causes of EARR. Root resorption produces root shortening and break down the integrity of teeth arch and it is very important for success of orthodontic treatment. The common, untoward consequence of moving a tooth through its supporting alveolar bone is that some of the root, generally in the apical region, is resorbed, though the teeth generally remain asymptomatic. *External apical root resorption (EARR) is the resorption of cementum and dentine and the resultant loss of root length*. EARR is more common in those treated orthodontically than in the untreated population.[4]

Inflammatory root resorption is a side effect related to the biological tissue response that enables teeth to be moved during orthodontic treatment. Mechanical forces are a key factor in the occurrence of external apical root resorption. Extensive orthodontic treatments are recognized as a major risk factor for increasing the prevalence and severity of root resorption. Especially heavy forces are most damaging. Radiographic examination of orthodontically treated patients showed some loss of root length. The maxillary incisors have been regarded as the most susceptible to root resorption, particularly those with blunt or pipette-shaped roots.[5]

Orthodontic treatment associated risk factors include the treatment duration, direction of tooth movement, magnitude of applied force, method of force application, and amount of apical displacement. Roots are three dimensional and studying root resorption with two-dimensional radiographs are difficult.[6] Levander and Malmgren presented a classification system for root resorption which is widely accepted in the orthodontic literature. According to this index, severity of root resorption increases from grade 1, defined as presence of irregular root contour, to grade 4, where root resorption is greater than 1/3 of the original root length. Previous studies reported a prevalence of root resorption greater than 2 mm (grades 3 and 4) of 10-18%.[7,8]

The appliance or technique used for an orthodontic treatment can be related to the degree of external apical root resorption. In addition, characteristics that are inherent to orthodontic treatment, such as type of brackets, the mechanics used, and the type and magnitude of the forces applied, are also relevant.

Therefore, the search for improved efficiency in orthodontic treatment has afforded new designs of brackets.[9] The most compelling potential advantages attributed to self-ligating brackets are a reduction in overall treatment time and less associated subjective discomfort. Others include more efficient chair side manipulations[10] and promotion of periodontal health due to poorer bio-hostability. These brackets are referred to as having less friction, a higher rate of dental movement, and shorter period of treatment.[11]

A hypothesis has been raised as to what may occur to tooth roots during dental movement. In fact, a faster correction of the malocclusion could lead to undesirable side effects, such as root resorption, which is a great concern for orthodontists.[9] Radiographic examination of orthodontically treated patients showed some loss of root length. Computed tomography scans have been regarded as the most precise tool in detecting root resorption. Since, CBCT is a more sensitive imaging modality for diagnostic and prognostic assessment of ARR. Therefore, cone beam computed tomography (CBCT) images showing root resorption may influence orthodontists in either continuing or modifying the treatment plan as needed.[9] The ability of cone-beam computed tomography to obtain distortion-free and reproducible images of single roots provides excellent possibilities to study root resorption.[12]

The purpose of this study is to compare the magnitude of external apical root resorption of maxillary incisors in patients undergoing the initial phase of orthodontic treatment, with self-ligating and conventional brackets with CBCT.

METHOD

This study comprised of 20 patients with Class I malocclusion with bimaxillary dentoalveolar protrusion into 2 equal groups based on bracket type & use i.e. Conventional (Ortho Organiser; Carlsbad C A, U.S.A.MBT 0.22 x 0.28) and Self- ligating brackets (Empower; American Orthodontics, Sheboygan, WI, U.S.A. MBT 0.22x 0.28). CBCT scans were obtained from all patients in two-time intervals, prior to the beginning of the orthodontic treatment (T0) and after the space closure (T1). All CBCT scans were carried out by a single experienced radiologist using the same tomographer. The EARR was calculated by assessing the difference in the total tooth length, which was measured from the incisal border to the root apex. relative root resorption (rRR) seen as the percentage shortening per tooth. Relative root resorption was calculated by the following formula:

rRR (Resorption per tooth in%) = ¼ (EARR *100%)/R1

where R1 = Root length before treatment

Inclusion criteria included Complete permanent dentition (excluding third molars). Bimaxillary protrusion cases with extraction of all four first premolars. Good general health (no significant medical history or drug use during the last month), and no anti-inflammatory or antibiotic medications taken in the month before the study. *Exclusion criteria* included Patient with poor periodontal condition, Patient with severe bone loss, and patient with known medical condition e.g. subacute bacterial endocarditis, diabetes, valvular disease, anemia etc.

STATISTICAL ANALYSIS

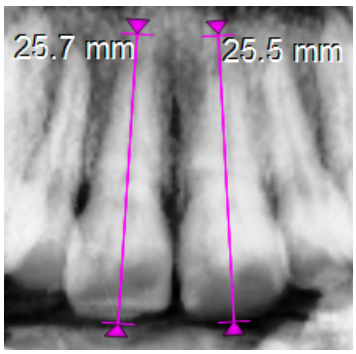
The data obtained was compiled systematically. A master table was prepared, and the total data was subdivided and distributed meaningfully and presented as individual tables along with graphs. Statistical analysis was done using Statistical Package of Social Science (SPSS Version 20; Chicago Inc., USA). Data comparison was done by applying specific statistical tests to find out the statistical significance of the comparisons. Quantitative variables were compared using mean values and qualitative variables using proportions. Significance level was fixed at $P < 0.05$. Statistical tests employed for the obtained data in our study were Chi-Square (□2) Test and Student's t-test:

RESULT

Group	Initial Root Length Right	Initial Root Length Left	Final Root Length Right	Final Root Length Left	Root Resorption (RR)	(L) RR	Space Closure
1 (Conventional Bracket)	21.50	21.60	21.20	21.40	0.30	0.20	23
	24.40	24.30	24.00	24.10	0.40	0.10	18
	22.80	22.80	22.50	22.50	0.30	0.30	19
	24.60	24.60	24.30	24.20	0.30	0.40	15

	21.50	21.30	21.10	21.00	0.40	0.30	16
	24.00	24.00	23.60	23.60	0.40	0.40	16
	22.60	22.60	22.30	22.20	0.30	0.10	18
	25.70	25.50	25.20	25.20	0.50	0.30	17
	21.40	21.50	21.10	21.30	0.30	0.20	16
	25.30	25.40	25.10	25.10	0.20	0.00	19

Table 1: Comparison of Root Length before treatment and after treatment in Right and Left Maxillary Central Incisor among group I (Conventional Brackets)



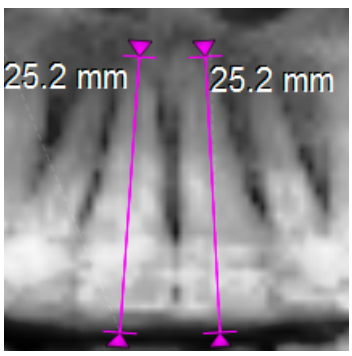


Figure 1: Pre Treatment and Post Treatment CBCT (Conventional Brackets)

Group	Initial Root Length Right	Initial Root Length Left	Final Root Length Right	Final Root Length Left	Root Resorption (RR)	(L) RR	Space Closure
2 (Self Ligating Brackets)	26.30	26.40	26.20	26.40	0.20	0.00	10
	26.30	26.30	26.20	26.10	0.10	0.20	7
	25.40	25.50	25.30	25.40	0.10	0.10	11
	25.40	25.20	25.40	25.10	0.00	0.10	12
	23.40	23.40	23.20	23.30	0.20	0.10	11
	22.40	22.50	22.40	22.40	0.00	0.10	10
	23.80	23.80	23.70	23.60	0.10	0.20	8
	24.50	24.40	24.40	24.30	0.10	0.10	10
	21.70	21.80	21.50	21.60	0.20	0.20	12
	20.20	20.20	20.20	20.10	0.00	0.10	9

Table 2: Comparison of Root Length before treatment and after treatment in Right and Left Maxillary Central Incisor among group II (Self Ligating Brackets).

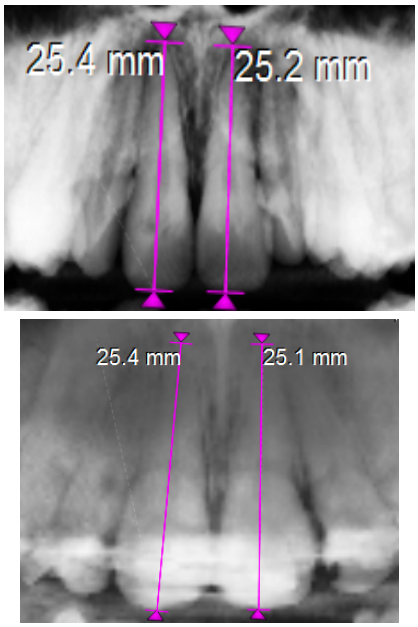
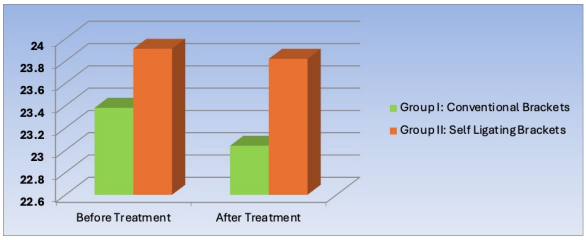


Figure 2: Pre Treatment and Post Treatment CBCT (Self-Ligating Brackets)

	Root Length (mm)					
	Before Treatment		After Treatment		Student 't' Test Value	Significance 'p' Value
Groups(Type of Brackets)	Mean	SD	Mean	SD		
Group I: Conventional Brackets	23.38	1.63	23.04	1.61	12.75	0.001(HS)
Group II: Self Ligating Brackets	23.91	2.02	23.82	2.01	3.857	0.004(HS)

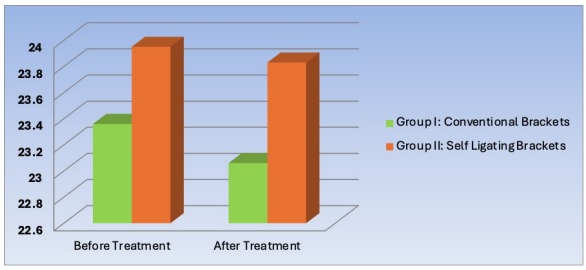
Table 3: Comparison of Root Length before treatment and after treatment in Right Maxillary Central Incisor among group I (Conventional Brackets) and group II (Self Ligating Brackets).



Graph 1: Comparison of Root Length before treatment and after treatment in Right Maxillary Central Incisor among group I (Conventional Brackets) and group II (Self Ligating Brackets).

	Root Length (mm)					
	Before Treatment		After Treatment		Student 't' Test Value	Significance 'p' Value
Groups(Type of Brackets)	Mean	SD	Mean	SD		
Group I: Conventional Brackets	23.36	1.6	23.13	1.58	11.619	0.001(HS)
Group II: Self Ligating Brackets	23.95	2.02	23.83	2.03	6	0.001(HS)

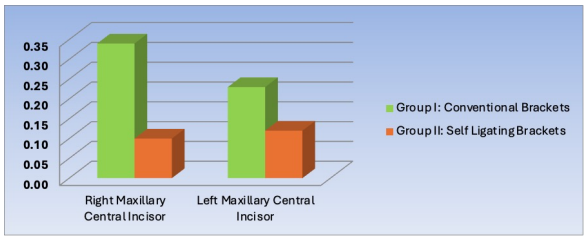
Table 4: Comparison of Root Length before treatment and after treatment in Left Maxillary Central Incisor among group I (Conventional Brackets) and group II (Self Ligating Brackets).



Graph 2: Comparison of Root Length before treatment and after treatment in Left Maxillary Central Incisor among group I (Conventional Brackets) and group II (Self Ligating Brackets).

	Root Resorption (mm)			
	Right Maxillary Central Incisor		Left Maxillary Central Incisor	
Groups(Type of Brackets)	Mean	SD	Mean	SD
Group I: Conventional Brackets	0.34	0.084	0.23	0.13
Group II: Self Ligating Brackets	0.10	0.081	0.12	0.06
Student 't' Test Value	6.466		2.351	
Significance 'p' Value	0.001(HS)		0.031(S)	

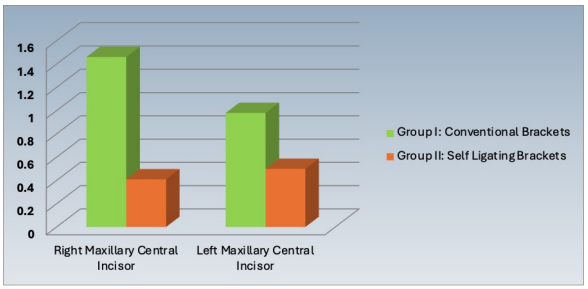
Table 5: Comparison of Root Resorption in Right and Left Maxillary Central Incisor among group I (Conventional Brackets) and group II (Self Ligating Brackets).



Graph 3: Comparison of Root Resorption in Right and Left Maxillary Central Incisor among group I (Conventional Brackets) and group II (Self Ligating Brackets).

	Relative Root Resorption (%)	
	Right Maxillary Central Incisor	Left Maxillary Central Incisor
Groups(Type of Brackets)	Mean %	Mean %
Group I: Conventional Brackets	1.46%	0.98%
Group II: Self Ligating Brackets	0.41%	0.50%

Table 6: Comparison of Relative Root Resorption (%) in Right and Left Maxillary Central Incisor among group I (Conventional Brackets) and group II (Self Ligating Brackets).



Graph 5: Comparison of Relative Root Resorption (%) in Right and Left Maxillary Central Incisor among group I (Conventional Brackets) and group II (Self Ligating Brackets).

DISCUSSION

External apical root resorption (EARR) is a sterile inflammatory process that is extremely complex and involves various disparate components, including mechanical forces, tooth roots, bone, cells, surrounding matrix, and certain known biologic messengers.[13]

It is an iatrogenic disorder that unpredictably occurs after orthodontic treatment, whereby the resorbed apical root portion is replaced with normal bone. RR is undesirable because it can affect the long-term viability of the dentition, and reports in the literature indicate that patients undergoing orthodontic treatment are more likely to have severe apical root shortening.[6] Since the greatest cause of root resorption in the population refers to orthodontic movement, a correlation exists between severity of the malocclusion and the degree of consequent root resorption. Segal et al.[14] indicated that the factors associated with duration of the active treatment may result in increased levels of ARR, and it was concluded that the apical displacement and total treatment duration proved to be highly correlated with the mean ARR. The teeth more susceptible to EARR are the maxillary and mandibular incisors. This might be caused by higher mechanical load due to their smaller root surfaces. Regardless of genetic or treatment-related factors, the maxillary incisors consistently average more apical RR than any other teeth, followed by the mandibular incisors and first molars.[6] As for the type of tooth movement, retraction has been suggested the movement where maximum tooth movement takes place. Lupi and Linge[15] reported the incidence of external apical RR (EARR) at 15% before treatment and 73% after space closure. Therefore, in this study we chose space closure as the time to evaluate the root resorption.

Few studies have dealt with the effects of mechanotherapy on EARR. Straight wire, Begg appliances, as well as various mechanotherapeutic approaches have been investigated.[16] But they had their shortcomings such as it was difficult to control tooth movements, difficulty in precise finishing, tedious wire bending, lack of understanding of complex dynamics of force and increased friction. As stated by Thompson W.J.[17] orthodontic appliances should be designed to satisfy denture, patient and doctor. An appliance that is able to achieve these goals more closely approaches the ideal treatment system. Self-ligating brackets and MBT system outperform Straightwire or Beggs appliances when compared.

Self-ligating brackets were developed with promises of eliminating ligatures by producing a continuous light force, thereby avoiding frequent appointments for replacement and creating a low friction environment at the bracket-arch wire interface, which allows better sliding mechanics and, as a consequence, decreases overall treatment duration. The decrease in the treatment time results in reduced risk of root resorption. As there is less treatment time the tooth is exposed to light forces for a shorter period of time hence, reduced root resorption.

The self-ligating brackets are divided into active and passive types. The Damon, Twinlock, SmartClip and EdgeLok brackets are all examples of passive bracket systems. These brackets are considered “passive” because the slide on these brackets opens and closes vertically, thus, creating a passive labial surface that does not change their slots’ dimensions. Advocates of passive brackets believe this larger slot allows for more tooth movement along the arch wire, thus, shortening treatment time.The In-Ovation R, SPEED and Time brackets are collectively categorized as active brackets. These brackets all have a closing mechanism that reduces the slot size in the horizontal dimension which will engage smaller arch wires than their passive counterparts. This allows a more complete initial alignment for a given size arch wireover a passive bracket. Fleming P et al[18] observed the relationship between self-ligating brackets and overall treatment time and concluded that self-ligating brackets were responsible for significantly reducing treatment times and visits without impairing the occlusal outcomes. The introduction of self-ligating brackets provoked the investigation of arch-wire ligation on EARR. Damon[19] suggested that the use of a nearly friction-free system, using self-ligating brackets and high-tech wires, may not cause the periodontal problems, including alveolar bone loss, which are typically associated with orthodontic treatment. The current literature supports that there is less friction during sliding mechanics with self-

ligating brackets. Liu et al[20] did a conventional comparative study on the apical root resorption between self -ligating and conventional brackets in extraction patients with the help of panaromic radiographs and concluded that no difference was found in the amount of EARR between the two groups. According to Chen et al.[21], the claim of reduced friction with self-ligating brackets is often cited as a primary advantage over conventional brackets (Damon, 1998b; Griffiths et al., 2005; Kim et al., 2008). This occurs because the usual steel or elastomeric ligatures are not necessary, and it is claimed that passive designs generate even less friction than active ones.

Roots are three dimensional and studying root resorption with two-dimensional radiographs are difficult. Different types of radiographs, including periapical, panoramic, cephalometric, were used along with various measuring methods to determine the extent of EARR.[23] Root resorption can be underestimated because of the inherent deficiency of panoramic x-rays to show EARR in a facial direction. The advantage of CBCT over CT includes a potentially lower radiation dose and the possibility of multiplane views and image manipulations.[24] The ability of cone beam computed tomography to obtain distortion-free and reproducible images of single roots provides excellent possibilities to study root resorption.[25] Dudic A. et al[26] compared panoramic radiography (OPT) with cone-beam computed tomography (CBCT) in evaluating orthodontically induced apical root resorption and found that apical root resorption after orthodontic tooth movement is underestimated when evaluated on OPT. CBCT might be a useful diagnostic method to conventional radiography, to be applied when a decision on continuation or modification of the orthodontic treatment is necessary because of orthodontically induced root resorption.

Therefore, cone beam computed tomography (CBCT) images showing root resorption may influence orthodontists in either continuing or modifying the treatment plan as needed.[6] Estrela C et al[27] evaluated a method to measure inflammatory root resorption (IRR) by using cone beam computed tomography (CBCT) and periapical radiographs and concluded that CBCT was useful in evaluation of IRR and its diagnostic performance was better than that of periapical radiographs. Lund H et al[25] did a study of cone beam computed tomography for assessment of root length and marginal bone level during orthodontic treatment and concluded that despite changes in tooth position CBCT yields a high level of reproducibility. Gilbert et al[28] studied 240 dental roots by CBCT and panoramic radiographs The CBCT had better results for identifying apical root resorption than panoramic radiograph.

The purpose of this study was to compare the external apical root resorption on maxillary central incisors with conventional and self-ligating brackets with the CBCT.

Investigations conducted by Dr. Stolzenberg's [29,30] and Eberting et al[32] also pointed out that there was a significant reduction in total treatment time and number of appointments in the groups treated with self-ligating brackets which ultimately helped in reducing one of the causative factors contributing to EARR (As discussed earlier, the contributing factors are *treatment duration, direction of tooth movement, magnitude of applied force, method of force application, and amount of apical displacement*).

Our study showed self-ligating brackets induced less apical root shortening measured in than conventional pre-adjusted brackets. Among group I, mean root length of right maxillary central incisor was reduced from 23.38±1.63 mm to 23.04±1.61mm while among group II, it reduced from 23.91±2.02 mm to 23.82±2.01. The mean root length significantly reduced by 0.34 mm in group I and 0.10 mm in group II patients. There was statistically significant difference in Root Length before treatment and after treatment in Right Maxillary Central Incisor for group I and group II respectively. (P=0.001 and 0.004).

Among group I, mean root length of left maxillary central incisor was reduced from 23.36±1.60 mm to 23.13±1.58 mm while among group II, it reduced from 23.95±2.02 mm to 23.83±2.03. The mean root length reduced by 0.23 mm in group I and 0.12 mm in group II patients. There was statistically significant difference in Root Length before treatment and after treatment in left Maxillary Central Incisor between group I (Conventional Brackets) and group II (Self Ligating Brackets) respectively. (P=0.001 &0.001).

This was in accordance with Kawashima et al[33] who studied external apical root resorption and the release on IL -6 in the gingival crevicular fluid induced by a self -ligating system on the maxillary central incisor and concluded that external root resorption in the self-ligating bracket was much lower than conventional brackets. A study done by Chen et al[21] according to the results of this study, self-ligating brackets induced less apical root shortening measured in periapical radio-graphs than conventional pre-adjusted brackets. However, there was no statistically significant difference was found in the comparison of the degree

of root resorption between the two groups. However, Leite et al[9] demonstrated that root resorption is similar in self-ligating and conventional ligating brackets during the initial treatment stage with CBCT that provides greater image accuracy.

In this study, among both right and left maxillary central incisor root Resorption was more in group I (Conventional Brackets) as compared to group II (Self -Ligating Brackets). Among conventional brackets, root resorption was more in right maxillary central incisor as compared to left. Mean root Resorption was 0.34±0.084 mm on right side and 0.23±0.13 mm on left side maxillary central. There was statistically highly significant difference in Root Resorption on right side between group I and group II (p=0.001)

While among self-ligating brackets root Resorption was more in left maxillary central incisor as compared to right. Mean root Resorption was 0.10±0.081 mm on right side and 0.12±0.06 mm on left side maxillary central incisor. There was statistically highly significant difference in Root Resorption on left side between group I and group II (p=0.031)

There was statistically significant difference in root resorption between right and left maxillary central incisor among group I (p=0.03). While among group II (p=0.538) there was no statistically significant difference between right and left maxillary central incisors.

The apparent difference of root resorption between right and left maxillary central incisor could be due to different preferential side for chewing. It could also be due to the different torque requirements by individual teeth. Though more studies are needed to understand this.

Padnis et al[34] investigated the amount of external apical root resorption (EARR) between conventional and passive self-ligating brackets, no difference was found in the amount of EARR between appliance systems. Patel N et al[18] utilized cone beam computed tomography (CBCT) to analyze the amount of linear root resorption that occurs in maxillary and mandibular permanent incisors and found no difference between the two groups in relation to mean root resorption.

In this study, relative root resorption was compared among both right and left maxillary central incisor in group I (Conventional Brackets) patients as compared to group II (Self Ligating Brackets). Among group I relative root Resorption was 1.46 % on right side and 0.98% on left maxillary central incisor while among group II, it was only 0.41% on right side and 0.50% on left side maxillary central incisor. There was statistically no significant difference in Right and Left Maxillary Central Incisor among group I (Conventional Brackets) and group II (Self Ligating Brackets). This was also seen in the study by Jacob C. et al1 which showed no significant impact of SL brackets on the rRR compared to non-SL brackets.

SUMMARY

External apical root resorption (EARR) is defined as either a physiologic or pathologic process with the loss of cementum or dentine resulting in a shortening of the root apex. This process is often associated with orthodontic treatment. Since EARR is a serious iatrogenic problem, there has been intensive research about EARR as an adverse effect during orthodontic treatment. As a result, many studies have underlined that EARR often develops during treatment with the fixed multibracket appliance. The teeth most affected by EARR are the maxillary and mandibular incisors indicating that mechanical factors might play an important role in the development of EARR.

The search for improved efficiency in orthodontic treatment with less adverse effects has generated new types of brackets. Self-ligating (SL) brackets are an innovation, which have been pioneered in the 1930s. These brackets provide a mechanism of closure for the inserted archwire, so no additional rubber elastics or steel ligatures are needed. A host of advantages such as shorter treatment time, higher rate of tooth movement and fewer appointments have been claimed relating to reduced frictional resistance of these brackets.

In the present study external apical root resorption between conventional and self-ligating brackets and on right and left maxillary central incisors and the time taken for space closure was compared. There was statistically significant difference in *Root Length* before treatment and after treatment in *Right Maxillary Central Incisor* for group I (Conventional Brackets) and group II (Self Ligating Brackets) respectively. (p=0.001 and 0.004). There was statistically significant difference in *Root Length* before treatment and after treatment in *left Maxillary Central Incisor* between group I (Conventional Brackets) and group II (Self Ligating Brackets) respectively. (p=0.001 &0.001). There was statistically highly significant difference in *Root Resorption* on *right side* between group I (Conventional Brackets) and group II (Self- Ligating Brackets) while on *left side* there was statistically significant difference between two groups respectively. (p=0.001 & 0.031). Among both *right and left maxillary central incisor relative root resorption* was more in group I (Conventional Brackets) patients as compared to group II (Self-

Ligating Brackets). however, it was not statistically significant respectively. (p=0.41 &0.50). There was statistically highly significant difference in *Root Resorption on right side* between group I (Conventional Brackets) and group II (Self Ligating Brackets) (p=0.001) while on *left* side there was statistically significant difference between two groups. (p=0.031)

CONCLUSION

In orthodontics, apical root resorption is the most common challenge faced by orthodontists. To overcome this challenge, there have been numerous attempts to come up with new innovations to solve this problem. Self-ligating brackets have the advantage of shorter treatment time, higher rate of tooth movement and fewer appointments. There is no additional need for ligature wires and modules hence also reducing the wire friction.

This study demonstrated that

- Relative root resorption was lower with self-ligating brackets when compared to conventional brackets, but it was not statistically significant.
- There was significant difference in Root Length before treatment and after treatment in Right and Left Maxillary Central Incisor for group I (Conventional Brackets) and group II (Self Ligating Brackets) respectively.
- There was highly significant difference in Root Resorption on right side between group I (Conventional Brackets) and group II (Self Ligating Brackets) while on left side there was statistically significant difference between two groups.
- The rate of space closure affects the rate of root resorption. The root resorption was lower with self-ligating brackets as the treatment duration was reduced.
- There was significant difference in Root Resorption between right & left maxillary central incisor among group I, while among group II, there was no significant difference between right and left maxillary central incisor.

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