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Comparative Evaluation of Novel 'S' Shape Post with Omega and Modified Omega-Shape Post in Primary Anterior Teeth: An in Vitro Study

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Abstract: ***Background**: Success of rehabilitation of Early childhood caries (ECC) following endodontic therapy with post and core depends on various factors and one such significant factor includes post design. Many conventional post shapes owing to their small surface area and inadequate adaptability to the canal provided unsatisfactory results. Thus, in this study, a novel 'S' shape post is designed and compared for retention, fracture resistance and failure type with omega and modified omega-shape post in primary anterior teeth. **Method**: Thirty three extracted maxillary anterior primary teeth were cut up to 1 mm above the CEJ and pulpectomy was performed with ZOE and 1mm layer of GIC leaving 3 mm space below CEJ for post placement. Teeth were randomly divided into 3 groups: Group I:S shape post, Group II: omega shape post & Group III: modified omega shape post. Core buildup and strip crowns were placed using composite material. Teeth were tested under Universal Testing Machine (UTM) & type of fracture were observed under digital microscope (DM). **Results**: Group II showed highest mean fracture resistance (251.3±48.50) followed by group II (180.9±15.81) and group III (81.15±10.33) respectively. Type I favorable fracture was observed in group III (100%) and Group I (81.81%) and type II unfavourable fracture seen in group II (100%) and group I (18.18%). **Conclusion**: 'S' shape post and omega shape post serves better retention & resistance than modified omega shape post. This novel 'S' shape post can be used as an alternative to conventional shapes for better retention along with less chances of unfavorable fractures that can be retreated.***

Keywords: Early childhood caries, primary anterior teeth, post design, fracture resistance, novel S-shape post

1. Introduction

Early childhood caries in the 12th most prevalent disease in children affecting 560 million children globally and 46.9% in India[1]. ECC is a type of rampant caries that spread rapidly and typically involving pulp and caries encircle the neck of the tooth to finally break, living behind only the roots[2]. Restoration of these fractured anterior teeth is very crucial due to their importance in preventing development of abnormal tongue habits and subsequent malocclusion, loss of vertical dimension, speech problems and aesthetic concern correlating to psychological problems[3,4]. Therefore, additional to endodontic treatment modalities it becomes imperative to use intracanal post to provide substructure to improve the retention and to re-establish the tooth morphology[4].

However, treatment of these fractured primary anterior teeth with post and core is more challenging due to the small crown structure, less root dentin thickness, structural differences in primary teeth compared to permanent teeth, less surface area for the bonding with relatively large pulp chamber and less fracture resistance of pulpectomy treated tooth[1,6]. In addition to this, the constant resorbing rate of roots in primary teeth makes an obligation to extend intracanal post only to cervical 3rd of root canal without exceeding 1/3rd of the root width at its narrowest dimension in order to prevent interference with the eruption of permanent successors[5].

Various types of intracanal posts are available based on different materials, post design, post length and diameter, fabrication and type of retention[7] that has been tried with controversial success rate[8,9]. Metallic posts are still considered to be the standard choice as they have stood the test of time[10].

Orthodontic wire post has been most commonly used in primary teeth with different shapes. It has advantages over the other types of post as it is a simple procedure, easy to fabricate, require less chairside time and inexpensive[11].

Shapes that are routinely used with stainless steel wire includes omega and modified omega shape post. The Omega shape post has debatable success rates[8,9]. This shape can be responsible for unfavourable radicular fracture owing to only 59% of retention rates[8]. In modified omega post, it is a direct adhesive restorative procedure with single straight wire adaptation to the internal walls and small surface of wire available for bonding. Therefore, these shapes do not always have satisfactory results due to their specific shape designs that corresponds to less retention and fracture resistance rates.

Thus, post design influences the success of post and core system making it an important factor to create a reliable substructure or a core restoration that enhances the retention of the core material to the tooth surface[12].

There is always quest for better and shape that will overcome all the drawbacks of previous posts and fulfil all the challenges of fractured teeth. So, our study is one of its kind, because the novel 'S' shape post has been designed with retention grooves, helix incorporated and different post space preparation that enhances the retention and resistance form of the post. It is introduced with the logic of increased surface area for bonding and retention of the core as well as making it a simple fabrication procedure for better cooperation from children during chairside appointment providing long successive crown restoration. This can overcome the risk of radicular that can occur due to excess masticatory force and thus less chances of retreatment required. Therefore, this study was carried out to evaluate and compare the retention and compressive strength and fracture type of new customized 'S' shape post, omega and modified omega shape post.

2. Methodology

The study was conducted after obtaining approval from the Institutional Ethical Committee of KVG Dental College, Sullia, D.K.

Thirty-three extracted maxillary anterior primary teeth were stored in physiological saline until pulpectomy was performed. Each tooth was embedded in a plaster of Paris square block so that X-rays can be taken on completion of each step (fig 1). The coronal portion of the tooth was cut up to 1 mm above the CEJ with the help of a wheel-shaped diamond bur (fig 2). Access to pulp chamber was gained with the help of round bur. Working length was determined with the help of K-file number 10 and 15. Cleaning and shaping was done using 21mm K files. Subsequently, canal was obturated with zinc oxide eugenol and sealed with a layer of Glass Ionomer Cement leaving 3 mm space below the CEJ for post placement. GIC was used as a barrier between zinc oxide eugenol and composite because eugenol interferes with the polymerization of composite resin. Mushroom shape post space was created 3mm below CEJ using number 4 round bur (fig 3). Post was placed into the canal to check for proper fitting. Etching was done for 20 s, washed and then dried with high pressure syringe for 5 s followed by Dentin Bonding Agent (DBA) application and curing for 20 s followed by flowable composite to build the core and light curing for 40 to 60 s. Teeth were randomly divided into 3 groups. Subjects were randomly allocated to the respective groups (n=11). Group I (n=11): S shape post Group II (n=11): Omega shape post. Group III (n=11): Modified omega shape post (fig 4).

Group I: Using Universal and Adams plier 0.7mm stainless steel wire was bent to form 'S' shape with helix incorporated in the lower curve of S such that the helix with lower curve incorporate the post space. Serration were made with the help of straight bur.

Group II- Using Universal and Adams plier 0.7 mm wire of length was used to bent into Omega shape post.

Group III- 0.7 mm wire of length was used to bent into modified Omega shape post post.

All post bent to form 5-6 mm of height such that 3 mm was inside the canal and 2 mm above the cement-enamel junction CEJ (fig 5). Flowable composite was placed into the canal and cured in two steps: first the post space with light cured flowable composite resin was cured and same was used to build the core. Crown build-up was done with flowable composite using strip crowns (fig 6&7). All the teeth were mounted onto acrylic resin blocks with the help of cold cure resin (fig 8) and stored in physiological saline at room temperature for 72 h before testing.

Testing: The teeth were placed on the lower crosshead of a Universal Testing Machine (UTM) and tested for fracture resistance (fig 9). The load (force) was applied at 1,000 N at a speed of 4 mm/min and increased in 0.1 g steps until the tooth fractured (fig 10). Mode of fracture and bond failure site were examined under a Stereomicroscope (SM) and the type of fracture and bond failure observed are as follows:

1) Type I fracture: Complete post and core dislodgment along with the crown (above CEJ) (fig 12)
2) Type II fracture: Complete post dislodgement along with the crown and part of root (below CEJ) (fig 13).

The data obtained from the study was tabulated and then subjected to statistical analysis using ANOVA and Paired t-test.

3. Results

Comparison of parameters among study groups with Two-way analysis of variance (ANOVA) and Post Hoc test (Table 1&2)

Statistical significant difference was observed among all groups ($p<0.05$) with highest mean value of all parameters of fracture resistance and retention in Group II (omega shape post) than group I (S shape post) and least among group III (modified omega shape post). The intergroup comparison showed the mean value of all parameters was significantly higher between each group except wrt percentage of strain and displacement at maximum where no statistically significant difference was found among group I and group II.

Comparison of type of fractures among study groups using chi-square test (Table 3 & g Graph 1)

Highly significant difference among the type of fracture exhibited by Group I, Group II and Group III with a P value < 0.01. There is a high statistically significant difference of type I favourable fracture found among Group I with 81.2% group II with 0% and group III with 100%. There is a high statistically significant difference of type II unfavourable fracture found among Group I with 18.8%, group II with 100% and group III with 0% (Table 3).

4. Discussion

According to AAPD protocol, rehabilitation of severely damaged primary after pulpectomy by intracanal posts is recommended to improve retention and resistance of crown restorations.

Various elements determine the post selection for primary teeth. These includes tooth anatomy, root length, post width, post adaptability and canal configuration, remaining coronal structure, torsional force, post design, post material, material compatibility, bonding ability of the tooth and adhesive materials used[11]. One such factor considered in our study is post design. Post design influences the torsional forces on the post and remaining tooth structure and enhances the retention features of the core and crown unit[14].

Earlier designs of orthodontic wire post which have been commonly used shown inconsistent success rates owing to reduced fracture resistance and retention form of the post. According to Aquaviva S et al, the post head design is crucial and lack of retentive features of the post head may reduce post to core retention[14]. Therefore, there was a need for new post design and in our study, we modified the stainless-steel orthodontic wire post into S shape design.

Our study evaluated the fracture resistance of the post shapes and the results showed that there was high significant difference ($p< 0.01$) among all three groups with highest mean fracture load was seen in group II with omega shape post (251.3±48.50) compared to group I with S shape post (180.9±15.81) and group III with modified omega shape post (81.15±10.33). The results can be attributed to the omega post ends contacting lateral walls of mushroom post space forming a tight contact within the canal[16-18]. The results are in accordance to Kirankumar Sudulakunta Vorse study with omega shape post and composite resin showed better resistance to fracture compared to polyethylene fibre post[6]. The results are in contrary to Priya Subramaniam study with omega shape post exhibiting lower retention and marginal adaptation compared to glass fibre post[10]. Our study is the first one to evaluate different shapes of Stainless-Steel wires.

Our study results showed that group I with novel S shape post exhibited moderate compressive when compared to group II but superior to group III. The results can be attributed to the design of novel S shape post owing to the mean fracture of 180.9±15.81. The S shape post design aims to enhance retention and resistance of the reconstructed teeth. Optimal balance should exist between the coronal and root canal of the tooth. However, longer length of posts is not recommended in primary teeth due to its negative effect on physiological resorption of the tooth[2,12]. Therefore, S shape with a helix incorporated in order to compensate for shorter length and to increase the potential surface area for the attachment of the post to withstand displacement forces. Retention of the post is enhanced by surface area bonding of the post available with root canal dentin. Hence, combination of Mushroom shape post space design and a helix incorporated in lower curve of S for effective locking mechanism. According to A.Baghalian et al, poor adhesion exists between the metal post and core material due the post material biocompatibility[13]. Serrations in the novel post were included as an added feature to provide micromechanical bond with the core material to compensate for non-chemical bonding of the metal post to the root dentin [21]. The ultimate aim of the novel S shape post design was to aid in creating a harmonious balance between post and core material with the remaining tooth structure within minimum chair side time not only to enhance fracture resistance and success rates but also indirectly requiring minimal cooperation from children aiding in behavioural shaping of uncooperative children. Therefore, it can be considered that the novel shape succeeded in exhibiting superior compressive and retentive strength in comparison with group III and moderate compared to group I.

On comparing all the groups, Group III with modified omega shape post showed least fracture resistance. The results contributing to the single straight wire incorporated inside canal. The post design neither engaged inverted mushroom shape post space design nor provided more surface of wire for bonding to the intracanal root surfaces. And also there was no retention from the post; instead, retention of the modified omega post inside the canal was due to core retention in mushroom shape post space.

Our study also evaluated for the type of fracture exhibited by all the three groups to determine the bond failure site. Fracture that occur above CEJ are repairable and below CEJ are unrepairable[22]. The types of fractures observed in the current study includes type I fracture with complete post and core dislodgment along with the crown (above CEJ) and Type II fracture with complete post dislodgement along with the crown and part of root (below CEJ). Our study results showed that all samples of modified omega shape post and 9 samples of S shape post showed type I fracture. However, mean value at which the fracture occurred for S shape post is higher than that of modified omega shape post. This is due to the fact that S shape post created less root canal whereas modified omega showed adhesive failure and poor bonding between the post and core.

All samples of group II with omega shape post and 2 samples of S shape post exhibited type II fracture below CEJ. Forcing the loop end of omega wire into a post space design of the root canal may decrease the distribution of internal stress at wire end and root dentin interface causing risk of fracture below the CEJ. The results are in accordance with Priya Subramaniam et al and kirankumar et al, due to the adherence between omega wire and dentinal wall was mechanical and inadequate adaptation to the internal walls causing post dislodge and radicular fracture under high masticatory forces[10]. A. Baghalian et al showed that omega shape post exhibited more of adhesive failure than cohesive failure compared to composite and GFCR posts stating that poor adhesion exist between metal post and core material used[13].

Additionally, fracture resistance and retention of post also depends on post space design, type of adhesive system used and obturation materials[24,26,44]. Inclusion of Post space design has synergistic effect on post & core retention and mushroom shaped post space served higher micromechanical bonding to the tooth[2,16]. Therefore, mushroom-shaped undercut technique was employed as a post space design in all the groups. On contrary, Srinivas et al showed that there is possibility of mushroom shape post space causing root weakening and lateral root perforation of thin dentinal root canal walls if not prepared with cautions[3].

In the current study zinc oxide eugenol was the material of choice for obturation as it is the golden standard for obturation in primary teeth recommended by AAPD. Alves and Vieira Rde and Viera and Ribeiro have concluded that the type of obturation material used for endodontic treatment does not interfere with mechanical properties of the post system. On the contrary, mohammad ahmed et al showed that the bonding strength were greater using metapex than

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when using Zinc oxide and Eugenol in the short composite post group[16]..

Restorations after post placement are also probable reason for failure after the reconstruction of extensively damaged anterior primary teeth[25,49,46]. In Our study included composite for core buildup and celluloid strip crowns for crown reconstruction due to its strength, resistance to wear and aesthetic results compared to Glass Ionomer Cement[12]. Gujjar et al stated that composite increases tensile bond strength of posts[26]. According to M Zalkind et al, GIC provided less retention compared to composite as core material[12]. However, contrary results were found by Pithan et al showing no significant differences in tensile bond strength between orthodontic wire, composite and glass fiber posts when they were cemented with a composite resin and also quoted that adhesion of the materials to dentinal root canal walls was more important than the type of post used as a retainer[27]. The same results were obtained by Pinherio et al who compared orthodontic wire, composite and dentin posts fixed with a dual cured adhesive material[16]. The type and shape of post and core buildup cement may explain the differences between our results and other studies.

Thus, distribution of the dentinal stress depends on the design of the post, post space design and post material[6].Even though novel modification of S shape of orthodontic wire post showed moderate fracture resistance and retention, it had an advantage of favorable fracture which can be retreated unlike omega shape post with unfavorable fracture posing difficult for retreatment leaving with an only option of extraction.

5. Limitations of the Study

The current invitro study doesn't simulate oral environment with periodontium (alveolar bone and periodontal ligament and cementum) surrounding the primary tooth which may alter the values of fracture load and retention. Universal Testing Machine produced unidirectional forces unlike masticatory forces in different directions. Obturating and adhesive materials might also influence the bonding strength of intracanal post. Therefore, large sample size with different obturating materials and adhesive materials are needed with long-term clinical studies to support the results of this study.

6. Conclusion

Within the limitations of the study it can be concluded that

1) The design of the orthodontic wire post had a greater effect on retentive and fracture resistance of primary anterior teeth along with post space design.
2) Novel 'S' shaped post exhibited better resistance & retention followed by omega shape post and least by modified omega shape post respectively.
3) Indeed, a short-post with S shape orthodontic wire post in conjunction with 360^0 mushroom-shaped post space undercut around the canal chamber helps enhance crown retention.

This novel 'S' shape can be used as an alternative to conventional post shape for long term success rate. However, additional clinical studies are necessary to document the performance and success of this novel shape post to restore anterior primary teeth.

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Figures

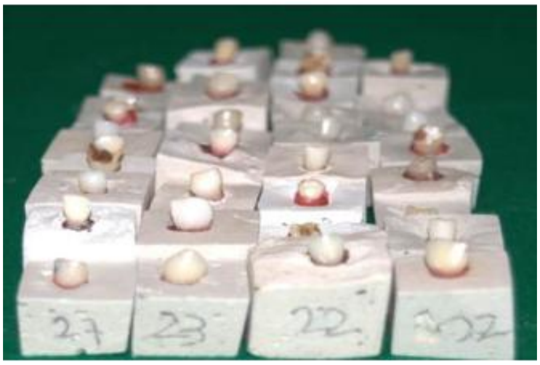

Figure 1: Selection and Randomization of sample

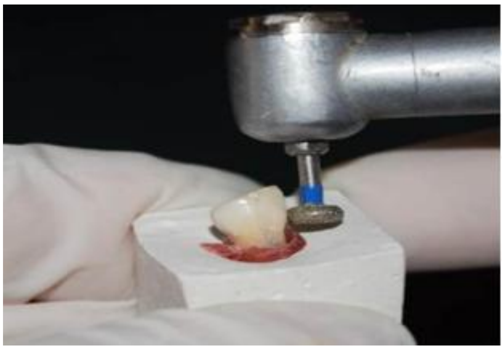

Figure 2: Tooth sectioning with Wheel bur

Figure 3: Radiographs of working length, obturation and mushroom post space preparation

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Figure 4: Post designs

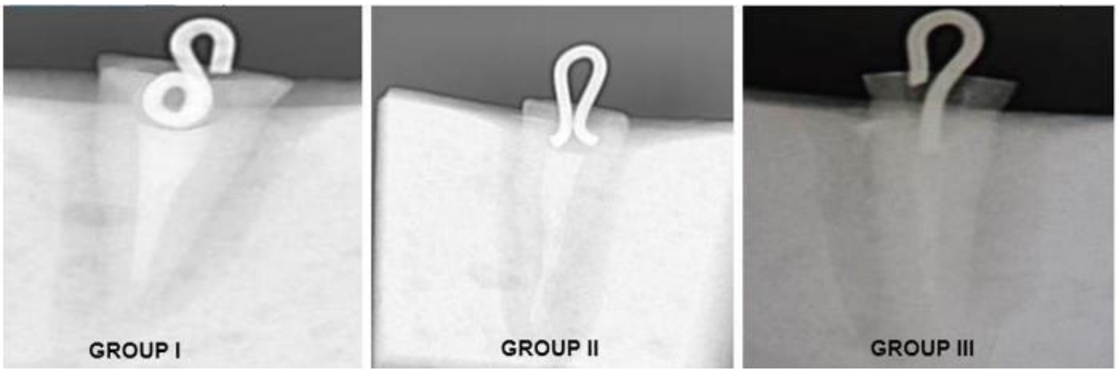


Figure 5: Radiographs of post placement into the canal

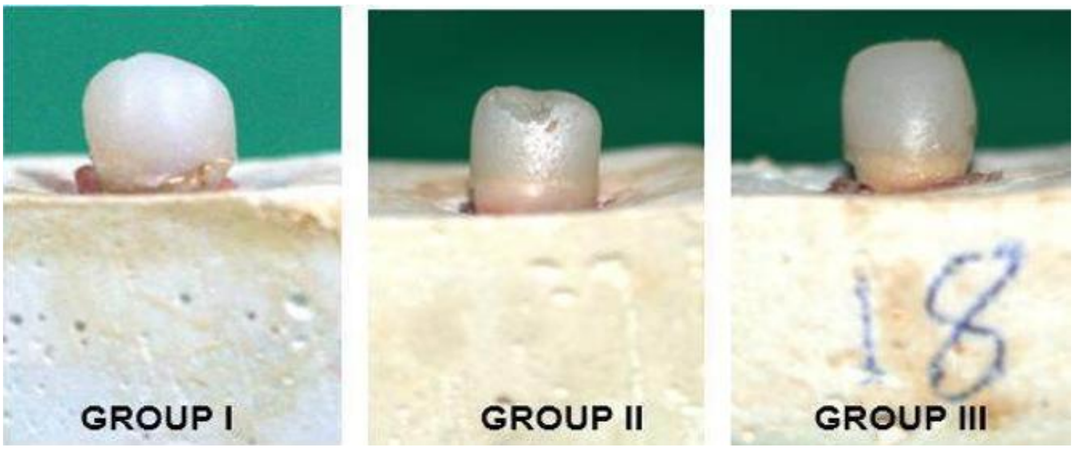


Figure 6: Clinical pictures of Post and crown buildup with strip crown

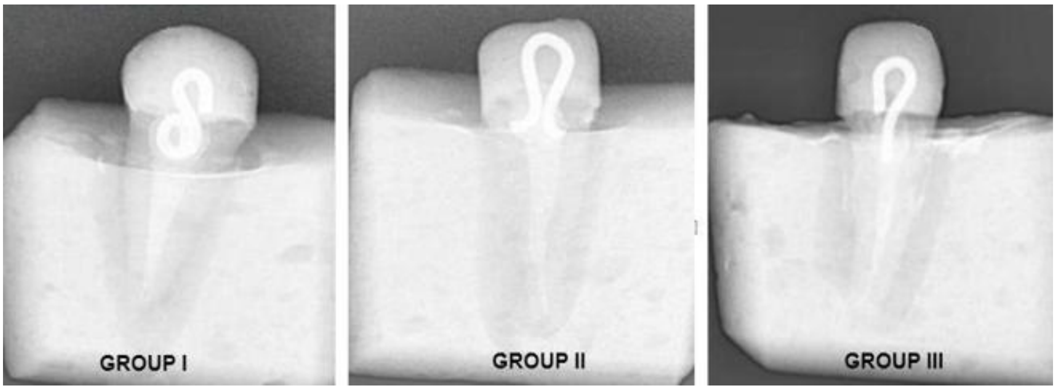


Figure 7: Radiographs of Post and crown buildup with strip crown

Figure 8: Teeth mounted with acrylic resin

Figure 9: Teeth with acrylic resin mounted on UTM

Figure 10: Sample fracture after maximum load resistance

Figure 12: Type I fracture

Figure 13: Type II fracture

Two way ANOVA Descriptives

Table 1: Comparison of study parameters among three groups using ANOVA Test

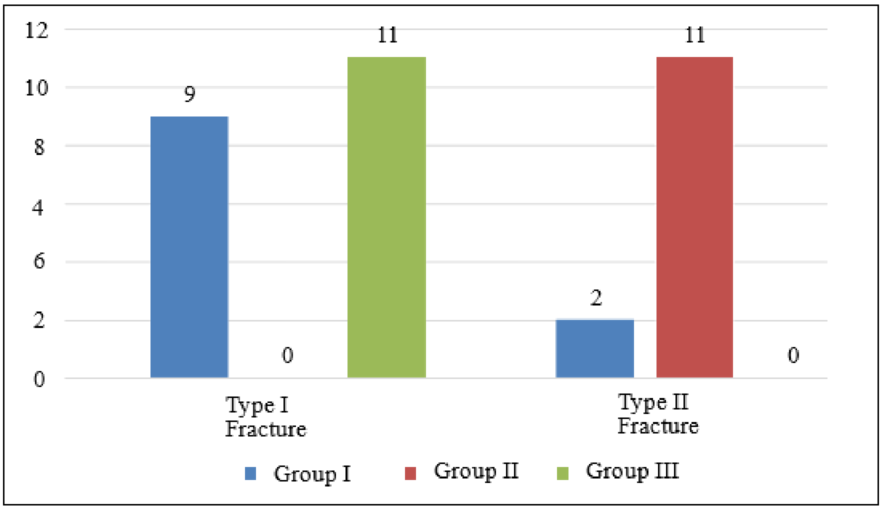
Parameters	Group I S shape post	Group II Omega shape post	Group III Modified omega shape post	P- Value
Number of samples tested	11	11	11	-
Load at maximum	180.9±15.81	251.3±48.50	81.15±10.33	0.000000000
Stress at maximum	3.067±0.28	4.58±0.52	1.31±0.11	0.000000000
Displacement at maximum	1.81±0.22	1.34±0.18	1.80±0.53	0.00531
Percentage of strain	8.22±0.37	7.48±0.25	8.73±0.97	0.000228
Load at yield	16.13±0.61	17.67±0.51	10.008±0.90	0.00000000

Table 2: Comparison of various parameters between various groups using post-hoc test

Parameters	Groups	Mean Difference (lower, upper)	p- value
Load at maximum	Group II – Group I	70.36 (38.77, 101.95)	0.000017
	Group III – Group I	-99.78(-131.37, -68.18)	0.000000
	Group III – Group II	-170.14 (-201.74, -138.55)	0.000000
Stress at maximum	Group II – Group I	1.51(1.14, 1.88)	0.000000
	Group III – Group I	-1.75(-2.12, -1.38)	0.000000
	Group III – Group II	-3.26(-3.64, -2.89)	0.000000
Displacement at maximum	Group II – Group I	-0.46(-0.84, -0.096)	0.0111442
	Group III – Group I	-0.012(-0.38, 0.35)	0.9963
	Group III – Group II	0.45(0.084, 0.82)	0.0136348
Percentage of strain	Group II – Group I	-0.74(-1.39, -0.091)	0.0228452
	Group III – Group I	0.50(-0.14, 1.15)	0.1556043
	Group III – Group II	1.24(0.59, 1.89)	0.0001517
Load at yield	Group II – Group I	1.54(0.81, 2.28)	0.0000401
	Group III – Group I	-6.12(-6.85, -5.38)	0.000000
	Group III – Group II	-7.66(-8.40, -6.93)	0.000000

Table 3: Comparison of type of fractures among study groups using chi-square test

Groups	Type I Fracture		Type II Fracture		P - value
	Frequency	Percentage	Frequency	Percentage	
Group I	9	81.2%	2	18.8%	0.000002101
Group II	0	0%	11	100%	
Group III	11	100%	0	0%	



Graph 1: Comparison of Type of fractures among the three groups of the study