# Evaluation of the Effect of Three Types of Rapid Maxillary Expanders (Conventional, Hybrid and MSE)

**NCT05446714**

**Date of the docement:14/5/2024**

**Statistical analysis**

Data management and statistical analysis were performed using the Statistical Package for Social Sciences (SPSS) version 20. Data were explored for normality by checking the data distribution and using Kolmogorov-Smirnov and Shapiro-Wilk tests. Comparisons of normally distributed numeric variables between groups was performed by ANOVA test followed by Bonferroni post hoc test whenever a significance difference was detected. Pre and post values was compared by paired t test.

The mean difference was calculated by the formula:(Value after-value before)

Difference data were non-parametric and were compared between groups using Kruskal Wallis test.

All p-values are two-sided. P-values $\leq 0.05$ were considered significant.

## Results

### I-Demographic data

**Age**: Patients age ranged from 11.7 to 15.8 years. There was no significant difference in age between groups (p=0.19), (Table 1, Fig.1)

**Cross bite:** In Butterfly hyrax, 73.3% of cases were bilateral, in comparison to 53.3% and 56.3% bilateral cases in Hybrid hyrax and MSE respectively; with no significant difference between groups (p=0.477), (Table 2, Fig.2)

**Malocclusion:** In Butterfly hyrax and Hybrid hyrax, 73.3% of cases were class 3, in comparison to 75% class 3 cases in MSE; with no significant difference between groups (p=0.993), (Table 3, Fig.3)

Table (1) Descriptive statistics and comparison between age between groups (ANOVA test)

| | Mean | Std. Dev. | Min | Max | P value |
|---|---|---|---|---|---|
| Butterfly hyrax | 14.50 | 1.04 | 11.70 | 15.80 | 0.190 ns |
| Hybrid hyrax | 13.96 | 1.21 | 11.70 | 15.40 | |
| MSE | 13.81 | .98 | 12.10 | 15.10 | |

Significance level p≤0.05, ns=non-significant

Table (2) Distribution of cases according to cross bite and comparison between age between groups (Chi square test)

| CROSS_BITE | Groups | | | P value |
|---|---|---|---|---|
| | Butterfly hyrax | Hybrid hyrax | MSE | |
| Unilateral | 4 (26.7%) | 7 (46.7%) | 7 (43.8%) | 0.477 ns |
| Bilateral | 11 (73.3%) | 8 (53.3%) | 9 (56.3%) | |
| Total | 15 | 15 | 16 | |

Significance level p≤0.05, ns=non-significant

Table (3) Distribution of cases according to cross bite and comparison between age between groups (Chi square test)

| MALOCCLUSION | Groups | | | P value |
|---|---|---|---|---|
| | Butterfly hyrax | Hybrid hyrax | MSE | |
| Class 1 | 4 (26.7%) | 4 (26.7%) | 4 (25%) | 0.993 ns |
| Class 3 | 11 (73.3%) | 11 (73.3%) | 12 (75%) | |
| Total | 15 | 15 | 16 | |

Significance level p≤0.05, ns=non-significant

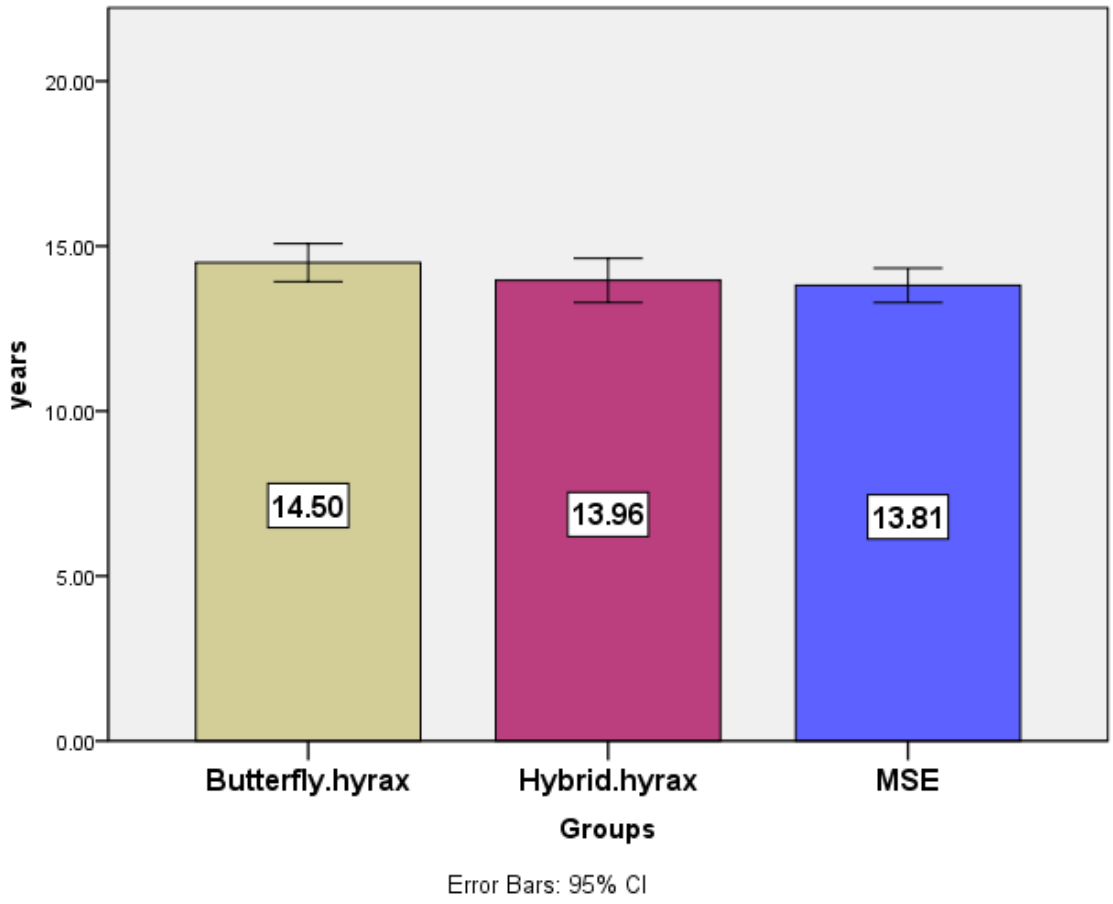


Fig. (1) Bar chart illustrating mean age in different groups

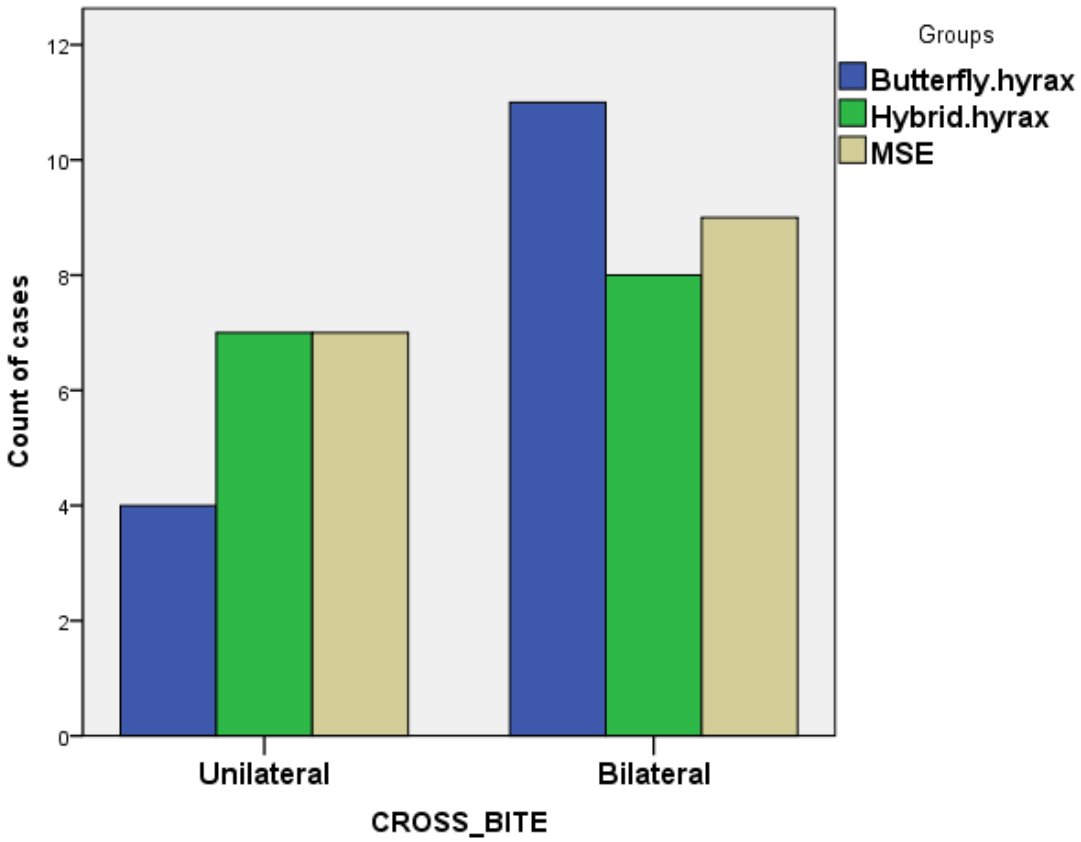


Fig. (2) Bar chart illustrating distribution of unilateral and bilateral cases in different groups

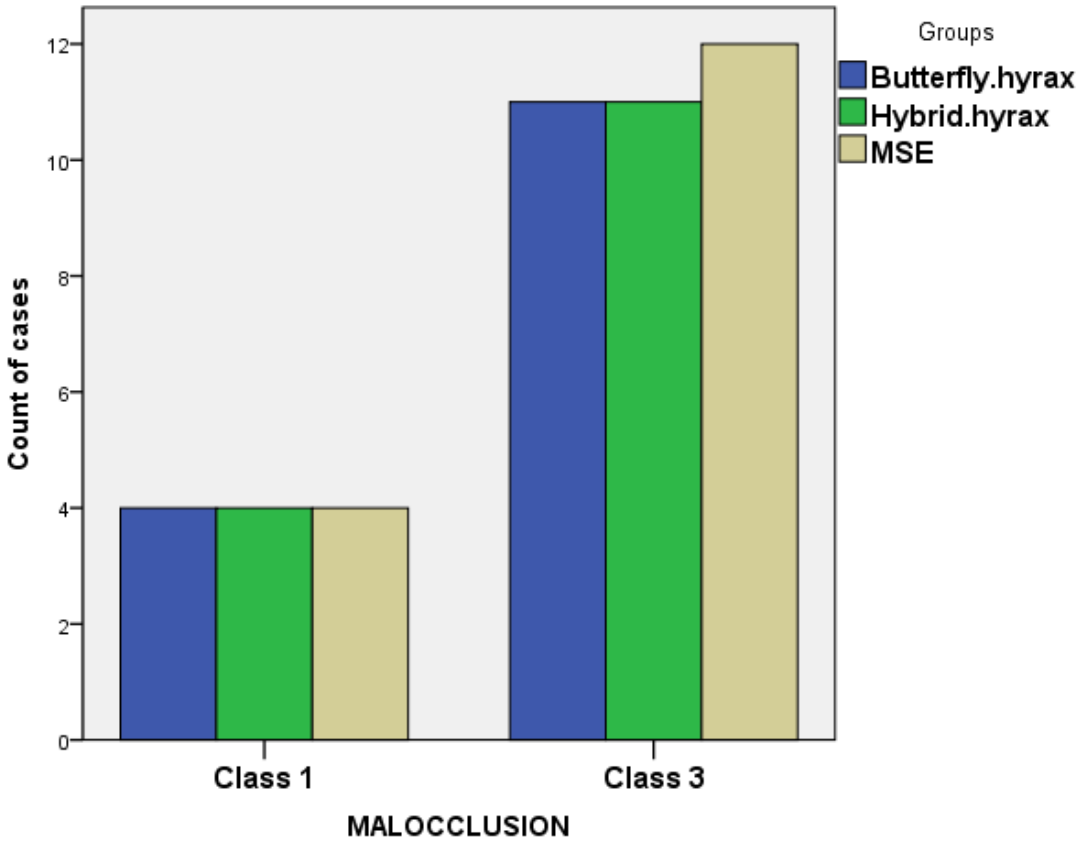


Fig. (3) Bar chart illustrating distribution of malocclusion classes in different groups

## II- Outcomes

# I- Comparison between Hybrid and conventional hydrax groups

- **Molar distance:** There was no significant difference between groups in pre values (p= 0.094). Regarding post treatment, The mean value recorded in Hybrid hyrax (52.21±2.59) was significantly higher than that recorded in Butterfly hydrax (49.43±2.41) (p= .016). Moreover, there was a statistically significant difference between groups regarding the amount of change (difference) by treatment (p=0.000), with the highest value recorded in MSE (8.88±1.58), followed by Hybrid hyrax (7.24±1.77) and the lowest value recorded in Butterfly hyrax (5.88 ± 1.39), (Table1, Fig.1, 11).
- **Premolar distance:** There was no significant difference between groups in pre values (p= 0.058). Regarding post treatment, The mean value recorded in Butterfly hydrax (43.67±2.55) and Hybrid hyrax (42.73±2.7) was significantly higher than that recorded in MSE (38.46 ±2.61), (p= .000). Moreover, the mean value of amount of change (difference) recorded in Butterfly hydrax (6.68±1.83) and Hybrid hyrax (6.08±1.84) was significantly higher than that recorded in MSE (4.43 ±1.82), (p= .005). (Table1, Fig.1, 11).
- **Molar rotation:** There was no significant difference between groups, regarding pre and post values (p= 0.175; p=0.207 respectively in right side and p=0.06; p=0.07 in left side). There was no significant difference between groups regarding the amount of change (difference) by treatment (p=0.503 in right side and p=0.757 in left side), (Table 1, Fig 2,12)
- **Premolar rotation:** there was no significant difference between groups, regarding pre and post values for the right side (p= .566; p=.609 respectively) and the left side (p=.455; p=.283 respectively). Moreover, there was no statistically significant difference between groups regrading the amount of change (difference by treatment in the right side and left sides (p=0.084; p= .410 respectively), (Table 1, Fig.3,12)

- **Nasal floor molar:** There was no significant difference between groups in pre values (p= 0.058) and post value (p=0.397). There was a statistically significant difference between groups regarding the amount of change (difference) by treatment (p=0.000), with the highest value recorded in MSE (4.38±0.85), followed by Hybrid hyrax (2.6±1.04) and the lowest value recorded in Butterfly hyrax (2.2± 1.49), (Table 2, Fig.4, 13).
- **Nasal floor premolar:** There was no significant difference between groups in pre values (p= 0.701). Regarding post treatment value, there was a statistically significant difference between groups (p=0.001), with the highest value recorded in MSE (39.73±2.27), followed by Hybrid hyrax (38.63±1.77) and the lowest value

recorded in Butterfly hyrax (37.04± 1.17). Moreover, regarding the amount of change (difference) by there was a statistically significant difference between groups (p=0.000), with the highest value recorded in MSE (4.87±0.62), followed by Hybrid hyrax (3.43±.74) and the lowest value recorded in Butterfly hyrax (2.47± 1.02), (Table 2, Fig.4, 13).

- **Hard palate maxillary width 6:** There was no significant difference between groups in pre values (p= 0.083). Regarding post treatment, the mean value recorded in MSE (64.31±1.8) was not significantly different from butterfly Hyrax (63.59±2.15), but was significantly higher than that recorded in Hybrid hyrax (62.04±2.68), (p= .023). The mean value of amount of change (difference) recorded in MSE (5.91±0.92) was significantly higher than that recorded in Butterfly hydrax (3.37±0.96) and Hybrid hyrax (3.17±1.54), (p= .000). (Table 2, Fig. 5, 14).
- **Hard palate maxillary width 4:** There was no significant difference between groups in pre values (p= 0.677). Regarding post treatment, the mean value recorded in MSE (40.34±1.56) was significantly higher than that recorded in butterfly hyrax (38.17±1.76), (p= .002). The mean value of amount of change (difference) recorded in MSE (6.35±1.25) was significantly higher than that recorded in Butterfly hydrax (4.51±1.28) and Hybrid hyrax (5.09±1.16), (p= .001). (Table 2, Fig. 5, 14).

- **Molar inclination:** There was no significant difference between groups, regarding pre and post values (p= 0.353; p=0.734 respectively in right side and p=0.312; p=0.892 in left side). The mean value of amount of change (difference) recorded in MSE was significantly higher than that recorded in Butterfly hydrax and Hybrid hyrax, (p= .000 in right side and p=0.003 in left side). (Table 2, Fig 6, 15)
- **Premolar inclination:** There was no significant difference between groups, regarding pre values (p= 0.191 in right side and p=0.355 in left side). Post treatment, the mean value recorded in Butterfly hyrax was significantly higher than the other groups (p=0.003 in right side and p=0.000 in left side). The mean value of amount of change (difference) recorded in MSE was significantly higher than that recorded in Butterfly hydrax and Hybrid hyrax, (p= .000 in right side and p=0.000 in left side). (Table 2, Fig 7, 15)

- **Arch depth:** There was no significant difference between groups, regarding pre values (p= 0.064). Post treatment, the mean value recorded in MSE was significantly lower than the other groups (p=0.007). The mean value of amount of change (decrease) recorded in MSE was significantly greater than that recorded in Butterfly hydrax and Hybrid hyrax, (p= .000 ), (Table 3, Fig 8, 16)

- **Incisor inclination:** There was no significant difference between groups, regarding pre and post values (p= 0.243 and p=0.922 respectively). The mean value of amount of change (decrease) recorded in MSE was significantly greater than that recorded in Butterfly hydrax and Hybrid hyrax, (p= .001), (Table 3, Fig 9, 18)

- **Anterior suture opening:** There was no significant difference between groups, regarding pre values (p= 0.290). The mean value recorded in MSE post treatment was significantly higher than that recorded in Butterfly hydrax and Hybrid hyrax, (p= .000). The mean value of amount of change (increase) recorded in MSE was significantly higher than that recorded in Butterfly hydrax and Hybrid hyrax, (p= .001), (Table 3, Fig 10, 18)

- **Posterior suture opening:** All groups recorded a value (0±0.00) pre-treatment. Post treatment, The mean value recorded in MSE was significantly higher than that recorded in Butterfly hydrax, while Hybrid hyrax recorded a significantly lower value than the other 2 groups (p= .000). The mean value of amount of change (increase) recorded in MSE was significantly higher than that recorded in Butterfly hydrax; while Hybrid hyrax recorded a significantly lower value than the other 2 groups (p= .000), (Table 3, Fig 10, 18)

## II-Comparison between pre and post values Hybrid and conventional hydrax groups

Comparing the pre and post values revealed than the post treatment value was significantly higher in post value compared to the pre value in molar and premolar distance (Fig.1), right and left molar rotation (Fig.2), right and left premolar rotation (Fig.3), nasal floor first premolar and molar (Fig.4), hard palate maxillary width first molar and premolar (Fig.5), right and left molar inclination (Fig.6), right and left premolar inclination (Fig.7) and anterior and posterior suture opening (Fig.10). On the other hand, Arch depth and incisor inclination recorded significantly lower post value compared to the pre value (Fig. 8,9), (Table 1-3)

Table (1) Descriptive statistics and comparison between (ANOVA test) and within group (i.e. between pre and post value) (paired t test) regarding molar and premolar distance; molar and premolar rotation right and left

| | GROUP | Pre | | Post | | Amount of change (post-pre) | | | P Within group |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Dev | Mean | Std. Dev | Mean | Std. Dev | Median | |
| Molar distance | Butterfly hyrax | 43.55 | 1.97 | 49.43[b] | 2.41 | 5.88[c] | 1.39 | 5.77 | .000* |
| | Hybrid hyrax | 44.79 | 4.27 | 52.21[a] | 2.59 | 7.42[b] | 1.77 | 7.50 | .000* |
| | MSE | 42.14 | 3.25 | 51.01[ab] | 2.56 | 8.88[a] | 1.58 | 8.95 | .000* |
| | P value bet. groups | .094ns | | .016* | | .000* | | | |
| Premolar distance | Butterfly hyrax | 36.99 | 4.60 | 43.67[a] | 2.55 | 6.68[a] | 1.83 | 6.20 | .004* |
| | Hybrid hyrax | 36.65 | 3.15 | 42.73 [a] | 2.70 | 6.08 [a] | 1.84 | 5.90 | .002* |
| | MSE | 34.03 | 3.12 | 38.46 [b] | 2.61 | 4.43[b] | 1.82 | 4.85 | .002* |
| | P value bet. groups | .058 ns | | .000* | | .005* | | | |
| Molar rotation right | Butterfly hyrax | 58.32 | 4.68 | 59.57 | 4.74 | 1.25 | .67 | 1.10 | .000* |
| | Hybrid hyrax | 61.50 | 4.54 | 62.54 | 4.42 | 1.04 | .58 | 1.10 | .000* |
| | MSE | 61.95 | 7.38 | 62.99 | 7.26 | 1.04 | .65 | 0.90 | .000* |
| | P value bet. groups | .175ns | | .207 ns | | .503 ns | | | |
| Molar rotation left | Butterfly hyrax | 59.75 | 5.31 | 61.17 | 5.27 | 1.42 | .51 | 1.50 | .000* |
| | Hybrid hyrax | 64.31 | 5.57 | 65.55 | 5.46 | 1.25 | .82 | 1.10 | .000* |
| | MSE | 60.43 | 5.65 | 61.90 | 5.54 | 1.48 | 1.06 | 1.20 | .000* |
| | P value bet. groups | .060 ns | | .070 ns | | .757 ns | | | |
| Premolar rotation right | Butterfly hyrax | 74.71 | 6.68 | 75.84 | 6.64 | 1.13 | .40 | 1.10 | .000* |
| | Hybrid hyrax | 73.79 | 6.58 | 74.71 | 6.48 | .93 | .48 | 0.90 | .000* |
| | MSE | 76.43 | 7.60 | 77.21 | 7.60 | .78 | .42 | 0.75 | .000* |
| | P value bet. groups | .566 ns | | .609 ns | | .084ns | | | |
| Premolar rotation left | Butterfly hyrax | 74.23 | 6.40 | 75.27 | 6.33 | 1.05 | .32 | 1.10 | .000* |
| | Hybrid hyrax | 76.99 | 6.07 | 78.65 | 5.55 | 1.65 | 2.50 | 1.10 | .000* |
| | MSE | 75.14 | 5.83 | 76.16 | 5.95 | 1.02 | .47 | 1.10 | .000* |
| | P value bet. groups | .455ns | | .283ns | | .410ns | | | |

Significance level $p \leq 0.05$, *significant, ns=non-significant

Post hoc test: Within the same comparison, means sharing the same superscript letter are not significantly different

Table (2) Descriptive statistics and comparison between (ANOVA test) and within group (i.e. between pre and post value) (paired t test) regarding nasal floor, hard palate maxillary width molar and premolar; molar and premolar inclination right and left

| | GROUP | Pre | | Post | | Amount of change (post-pre) | | | P Within group |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Dev | Mean | Std. Dev | Mean | Std. Dev | Median | |
| Nasal floor 1st.molar | Butterfly hyrax | 65.13 | 5.07 | 67.33 | 1.67 | 2.20 [b] | 1.49 | 1.80 | .003* |
| | Hybrid hyrax | 63.48 | 3.13 | 66.08 | 2.80 | 2.60[b] | 1.04 | 2.40 | .000* |
| | MSE | 62.00 | 3.36 | 66.38 | 3.07 | 4.38[a] | .85 | 4.45 | .000* |
| | P value bet. groups | .058ns | | .397ns | | .000* | | | |
| Nasal floor 1st.premolar | Butterfly hyrax | 34.57 | 1.55 | 37.04[c] | 1.17 | 2.47[c] | 1.02 | 2.40 | .001* |
| | Hybrid hyrax | 35.21 | 2.09 | 38.63[b] | 1.77 | 3.43[b] | .74 | 3.50 | .000* |
| | MSE | 34.86 | 2.40 | 39.73[a] | 2.27 | 4.87[a] | .62 | 5.00 | .000* |
| | | .701ns | | .001* | | .000* | | | |
| Hard palate Maxillary width 6 | Butterfly hyrax | 60.43 | 2.49 | 63.59[ab] | 2.15 | 3.17 [b] | 1.54 | 3.10 | .000* |
| | Hybrid hyrax | 58.67 | 2.99 | 62.04[b] | 2.68 | 3.37[b] | .96 | 3.40 | .000* |
| | MSE | 58.39 | 2.44 | 64.31[a] | 1.80 | 5.91[a] | .92 | 6.10 | .000* |
| | P value bet. groups | .083ns | | .023* | | .000* | | | |
| Hard palate Maxillary width 4 | Butterfly hyrax | 33.66 | 1.85 | 38.17[b] | 1.76 | 4.51[b] | 1.28 | 4.50 | .001* |
| | Hybrid hyrax | 34.22 | 1.79 | 39.31[ab] | 1.39 | 5.09[b] | 1.16 | 4.90 | .001* |
| | MSE | 33.99 | 1.58 | 40.34[a] | 1.56 | 6.35[a] | 1.25 | 6.10 | .003* |
| | P value bet. groups | .677ns | | .002* | | .001* | | | |
| Right.1st molar inclination | Butterfly hyrax | 18.58 | 4.41 | 24.24 | 5.32 | 5.66[a] | 1.52 | 5.80 | .000* |
| | Hybrid hyrax | 18.43 | 5.33 | 23.27 | 5.20 | 4.85 [a] | 2.10 | 6.00 | .000* |
| | MSE | 20.74 | 5.06 | 22.82 | 4.77 | 2.08[b] | 1.30 | 1.70 | .000* |
| | P value bet. groups | .353ns | | .734ns | | .000* | | | |
| Left.1st molar inclination | Butterfly hyrax | 18.45 | 4.34 | 23.67 | 6.07 | 5.21[a] | 2.74 | 6.30 | .000* |
| | Hybrid hyrax | 19.09 | 3.08 | 23.71 | 3.68 | 4.62[a] | 1.62 | 4.90 | .000* |
| | MSE | 20.49 | 3.78 | 23.01 | 3.53 | 2.52[b] | 1.31 | 2.35 | .000* |
| | P value bet. groups | .312ns | | .892ns | | .003* | | | |
| Right.1st premolar inclination | Butterfly hyrax | 6.70 | 2.51 | 11.72[a] | 3.96 | 5.02[a] | 2.18 | 5.90 | .000* |
| | Hybrid hyrax | 6.43 | 1.56 | 8.34[b] | 1.63 | 1.91[b] | .98 | 1.60 | .000* |
| | MSE | 7.76 | 2.16 | 8.72 [b] | 2.37 | .96 [b] | .51 | 0.90 | .000* |
| | P value bet. groups | .191ns | | .003* | | .000* | | | |
| Left.1st premolar inclination | Butterfly hyrax | 7.37 | 2.39 | 12.46[a] | 3.48 | 5.09[a] | 5.09 | 5.80 | .003* |
| | Hybrid hyrax | 6.57 | 1.60 | 8.63[b] | 1.51 | 2.06[b] | 2.06 | 2.20 | .000* |
| | MSE | 7.61 | 2.17 | 8.41[b] | 2.08 | .80[c] | .80 | 0.70 | .000* |
| | P value bet. groups | .355ns | | .000* | | .000* | | | |

Significance level p≤0.05, *significant, ns=non-significant

Post hoc test: Within the same comparison, means sharing the same superscript letter are not significantly different

Table (3) Descriptive statistics and comparison between (ANOVA test) and within group (i.e. between pre and post value) (paired t test) regarding arch depth; incisor inclination

| | GROUP | Pre | | Post | | Amount of change (post-pre) | | | P Within group |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Dev | Mean | Std. Dev | Mean | Std. Dev | Median | |
| Arch depth | Butterfly hyrax | 26.92 | 2.87 | 26.19[a] | 2.47 | -.74[a] | .38 | -0.70 | .000* |
| | Hybrid hyrax | 25.93 | 2.47 | 25.39[a] | 2.43 | -.53[a] | .22 | -0.50 | .000* |
| | MSE | 24.72 | 2.25 | 23.38[b] | 2.41 | -1.34[b] | .60 | -1.30 | .000* |
| | P value bet. groups | .064ns | | .007* | | .000* | | | |
| Incisor inclination | Butterfly hyrax | 117.31 | 3.65 | 114.46 | 3.37 | -2.85[a] | 2.00 | -2.80 | .000* |
| | Hybrid hyrax | 118.45 | 4.29 | 114.67 | 4.30 | -3.79[a] | 1.80 | -3.70 | .000* |
| | MSE | 120.05 | 5.32 | 114.63 | 5.79 | -5.43[b] | 1.48 | -5.30 | .000* |
| | | .243 ns | | .992 ns | | .001* | | | |
| Anterior suture opening | Butterfly hyrax | .09 | .27 | 3.57[b] | .47 | 3.47[b] | .34 | 3.50 | .004* |
| | Hybrid hyrax | .27 | .44 | 3.93[b] | .64 | 3.67[b] | .36 | 3.70 | .000* |
| | MSE | .30 | .42 | 5.99[a] | .46 | 5.69[a] | .33 | 5.70 | .002* |
| | P value bet. groups | .290 ns | | .000* | | .000* | | | |
| Posterior suture opening | Butterfly hyrax | .00 | .00 | 2.14[c] | .44 | 2.14[c] | .44 | 2.20 | .000* |
| | Hybrid hyrax | .00 | .00 | 3.06[b] | .37 | 3.06[b] | .37 | 3.10 | .000* |
| | MSE | .00 | .00 | 5.16[a] | .49 | 5.16[a] | .49 | 5.05 | .000* |
| | P value bet. groups | --- | | .000* | | .000* | | | |

Significance level $p \leq 0.05$, *significant, ns=non-significant

Post hoc test: Within the same comparison, means sharing the same superscript letter are not significantly different

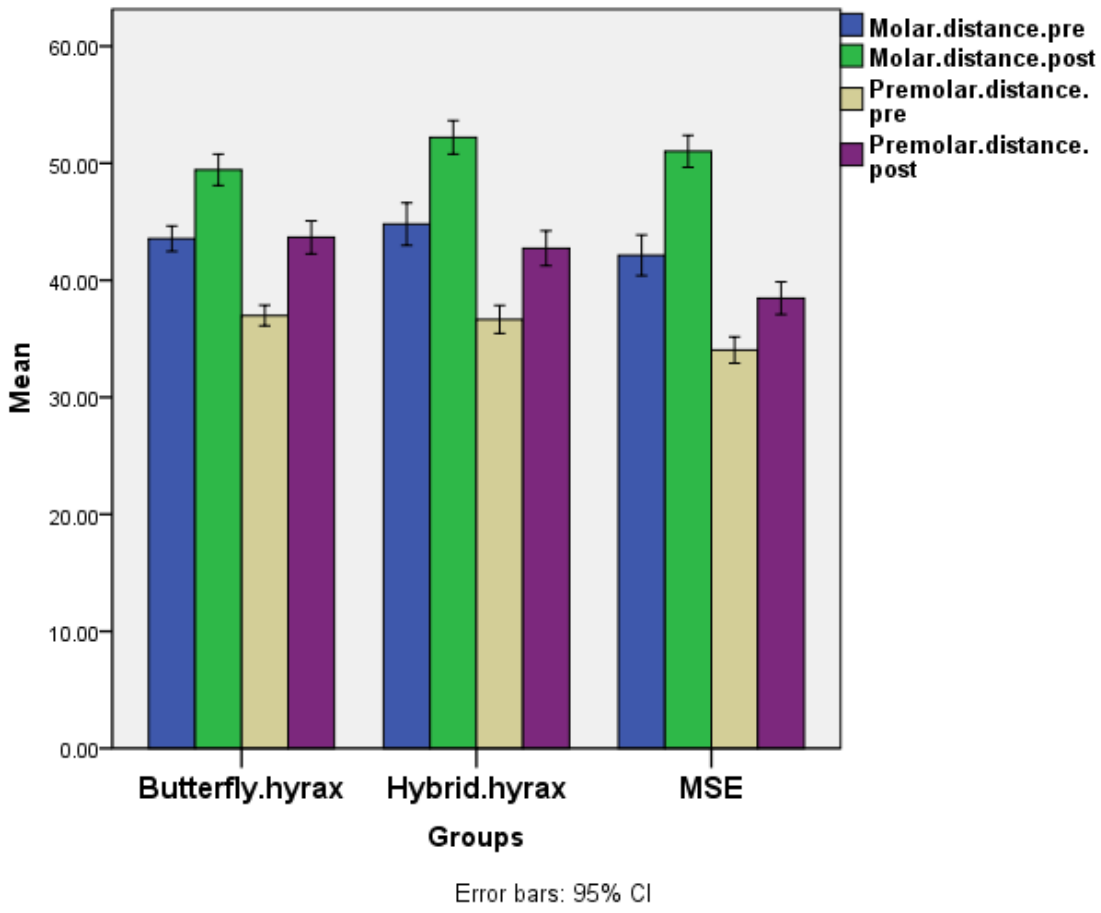


Fig. (1) Bar chart illustrating mean value of molar and premolar distances in different groups

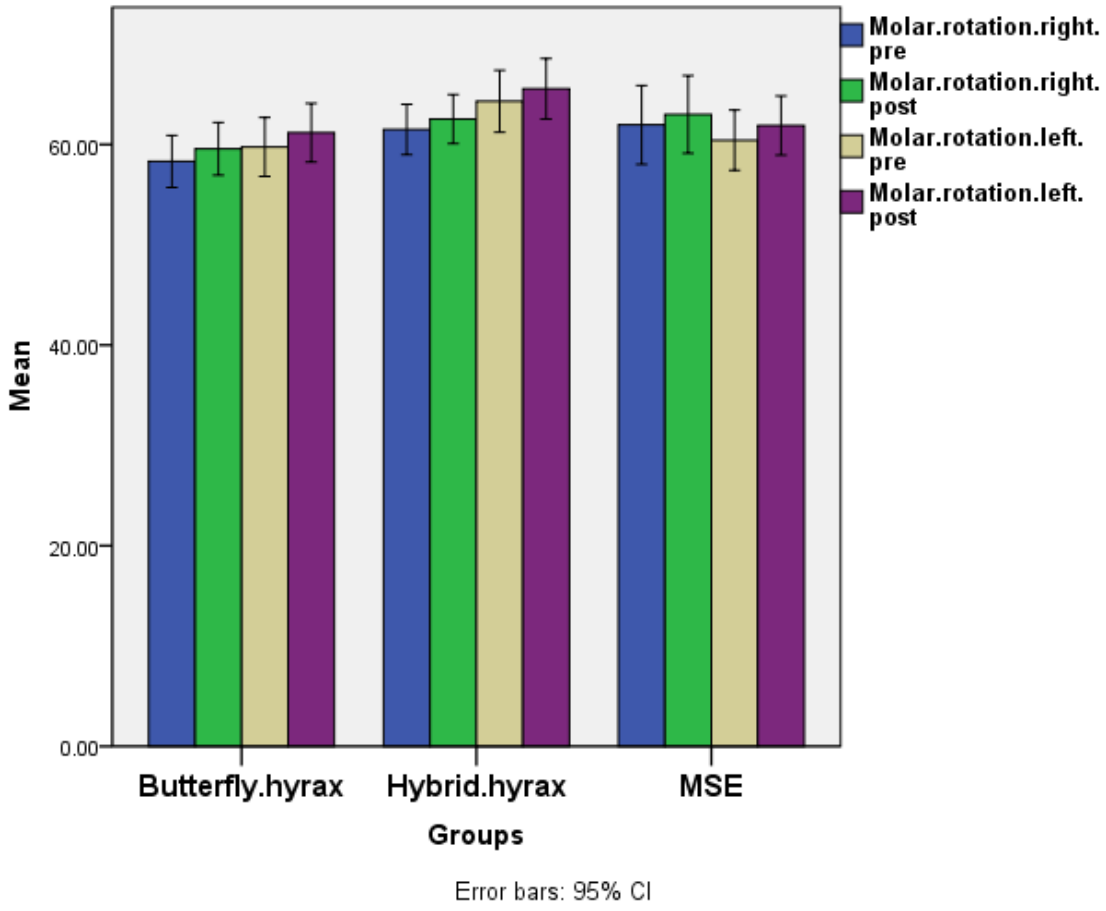


Fig. (2) Bar chart illustrating mean value of molar rotation in different groups

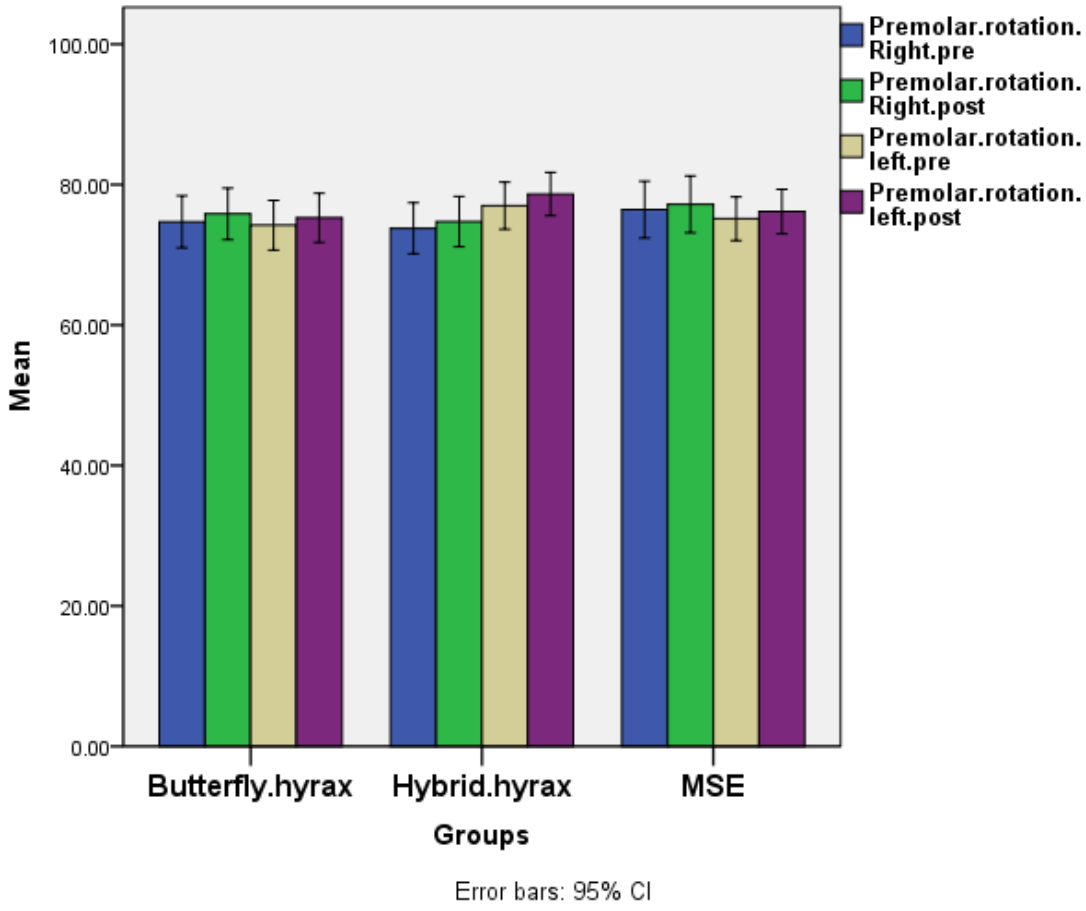


Fig. (3) Bar chart illustrating mean value of premolar rotation in different groups

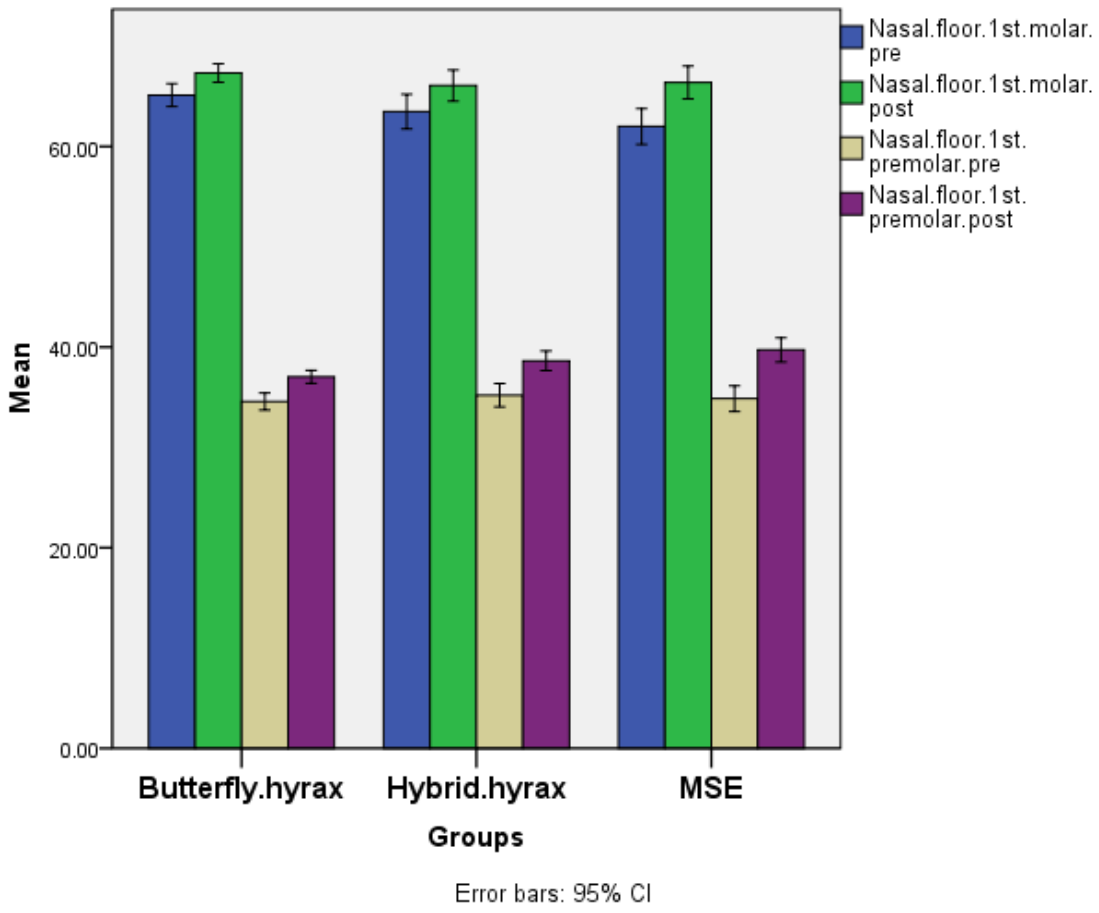


Fig. (4) Bar chart illustrating mean value of nasal floor first molar and premolar in different groups

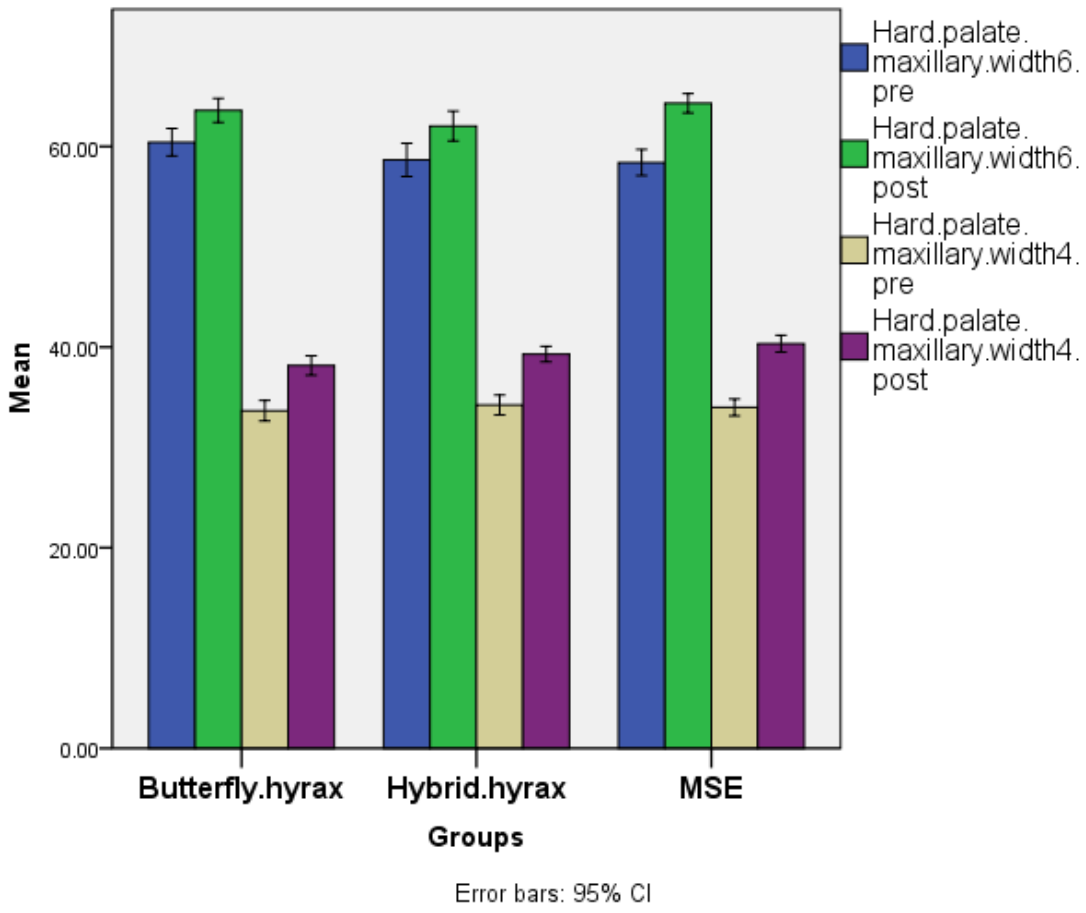


Fig. (5) Bar chart illustrating mean value of hard palate maxillary width first molar and premolar in different groups

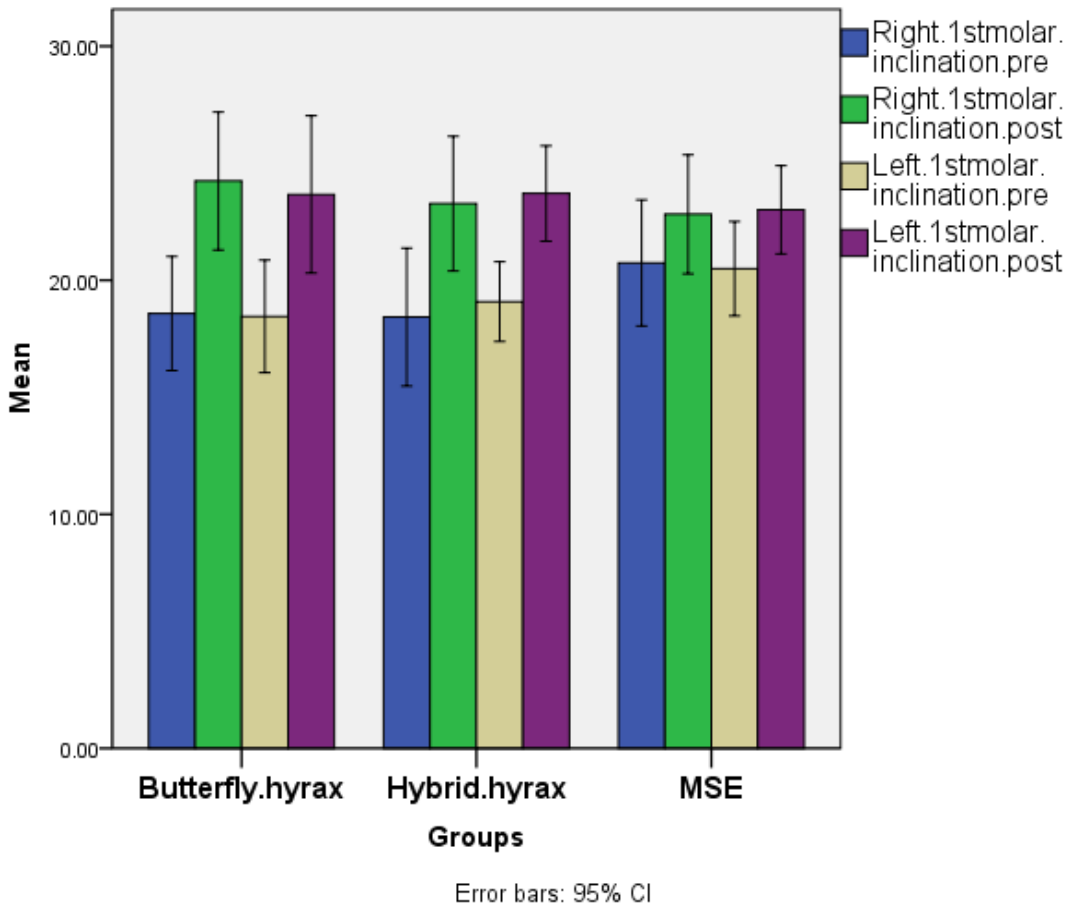


Fig. (6) Bar chart illustrating mean value of molar inclination in different groups

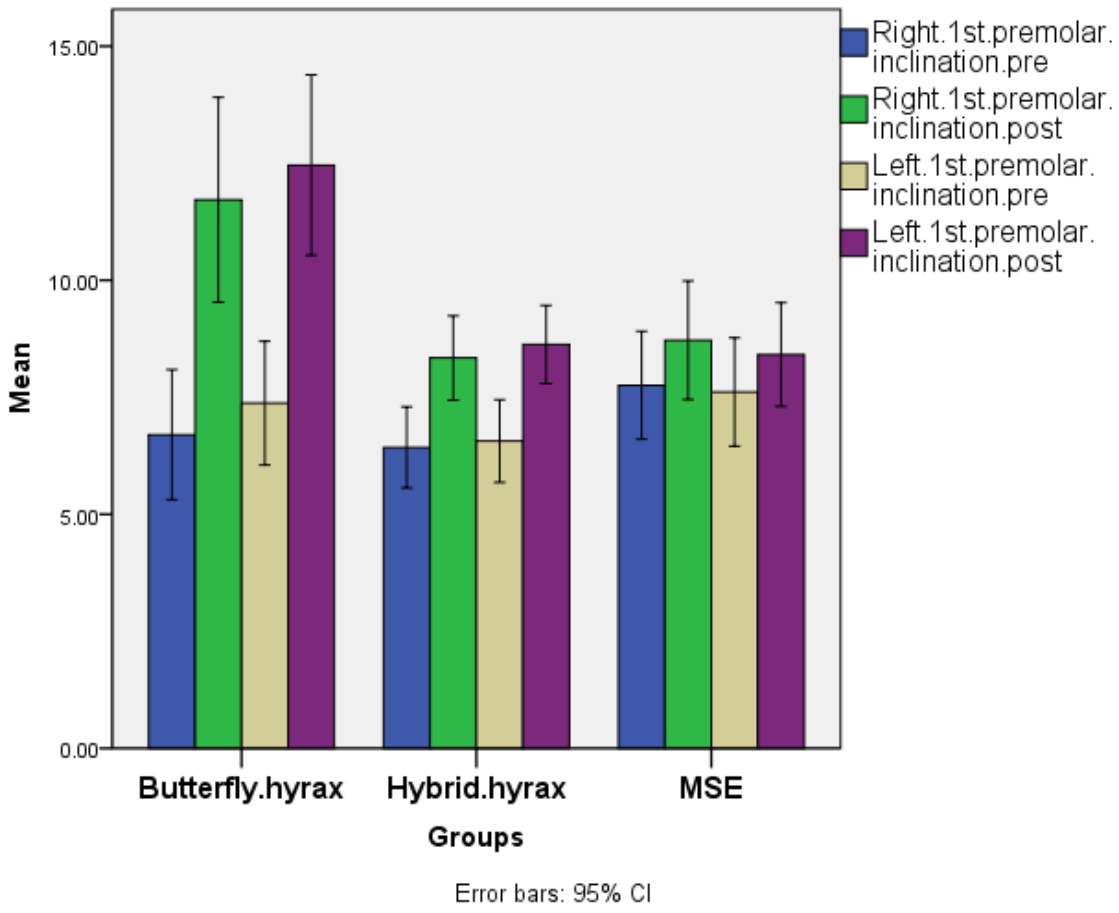


Fig. (7) Bar chart illustrating mean value of premolar inclination in different groups

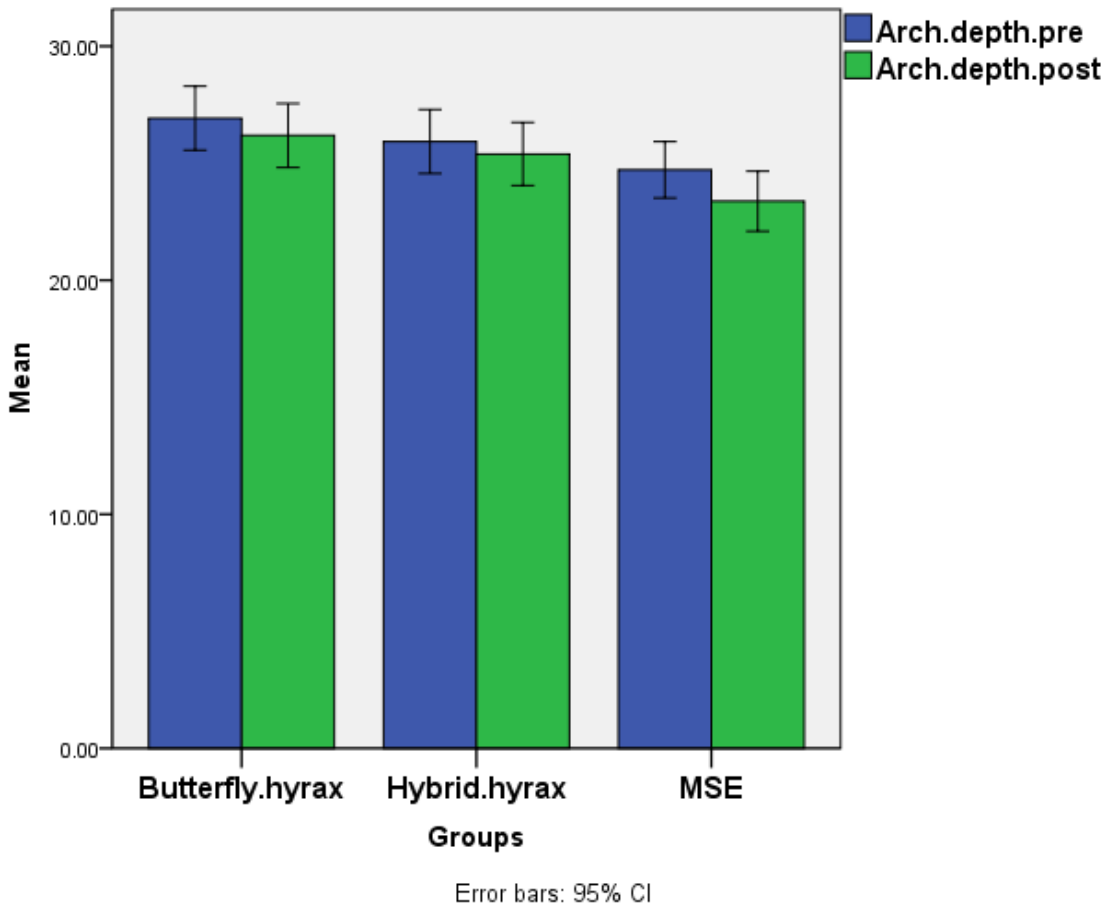


Fig. (8) Bar chart illustrating mean value of arch depth in different groups

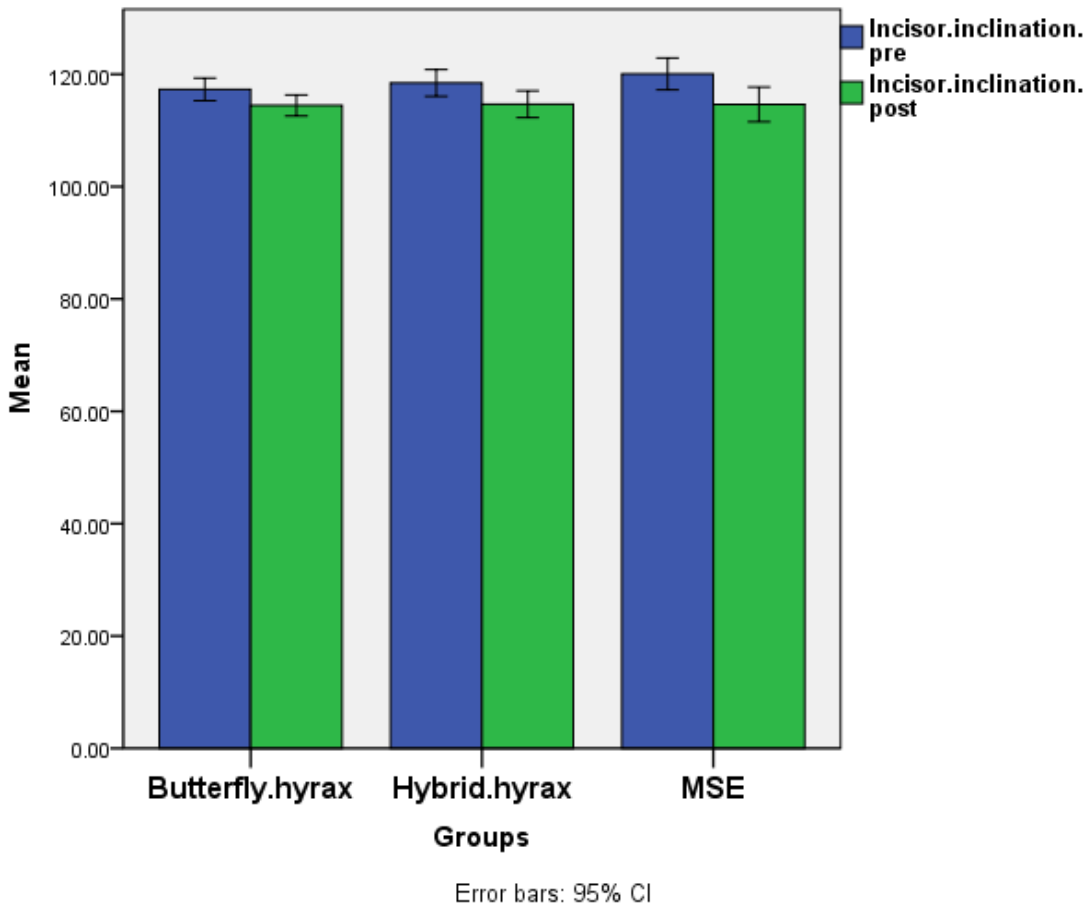


Fig. (9) Bar chart illustrating mean value of incisor inclination in different groups

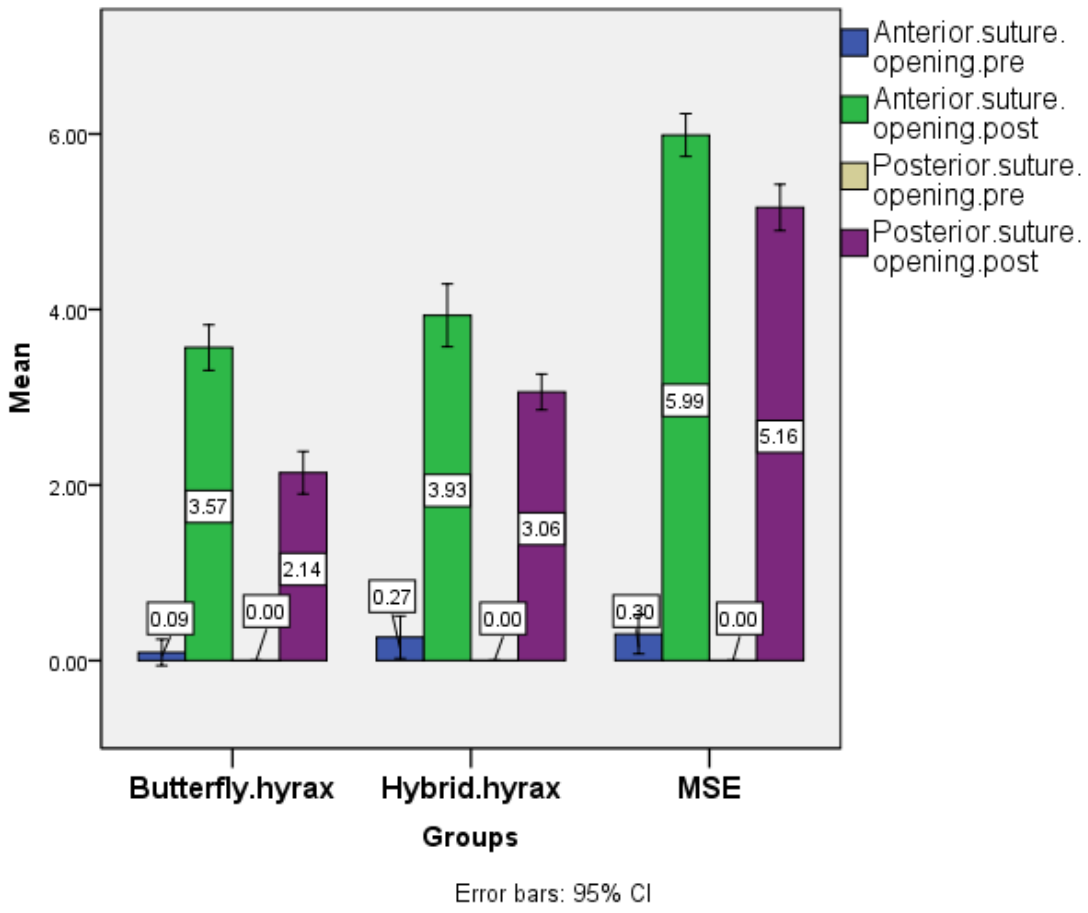


Fig. (10) Bar chart illustrating mean value of anterior and posterior suture opening in different groups

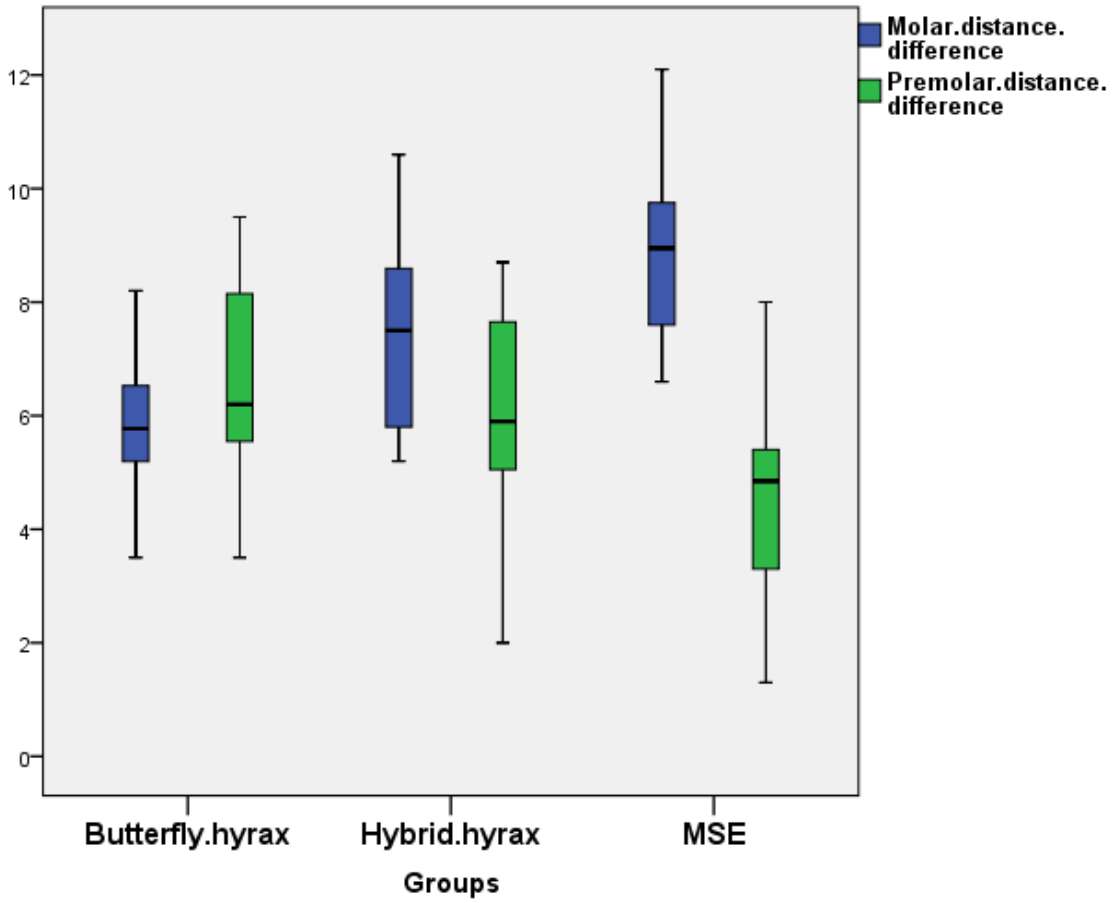


Fig. (11) Box plot illustrating value of difference in molar and premolar distance in different groups

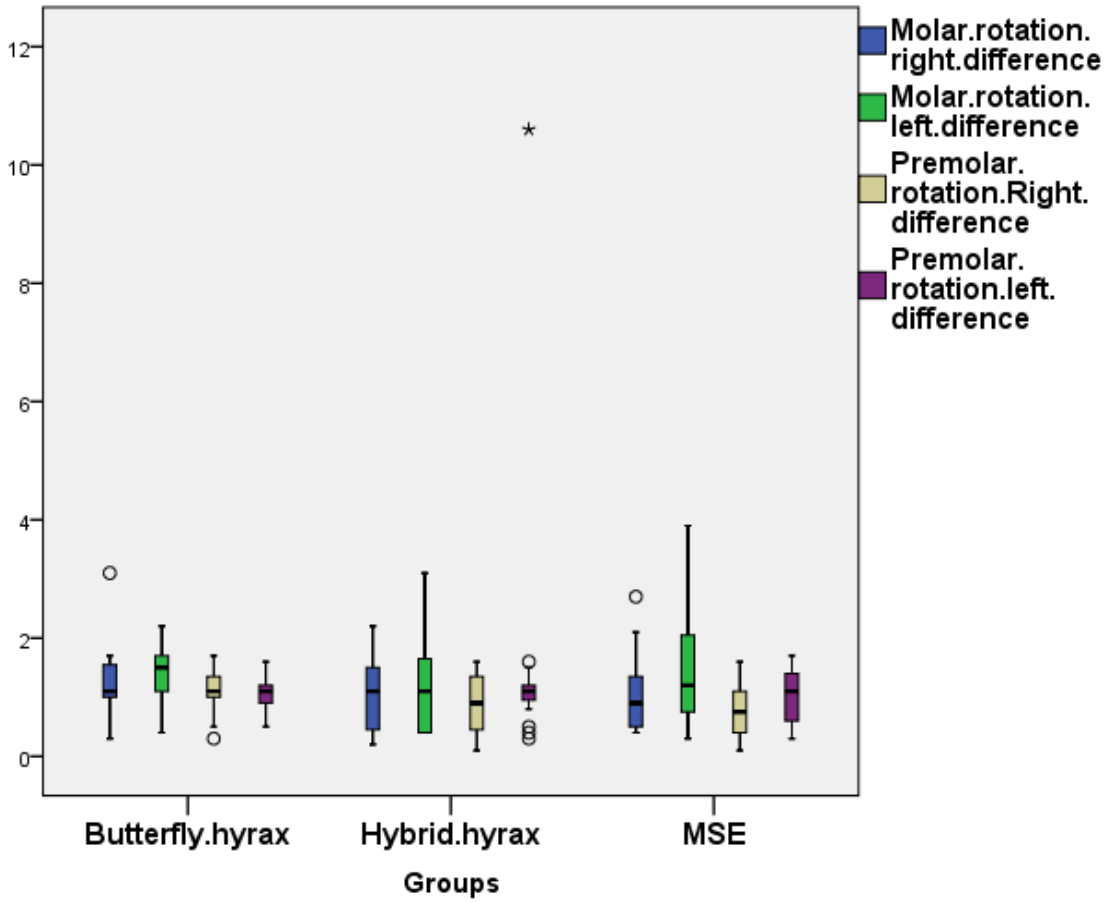


Fig. (12) Box plot illustrating value of difference in molar and premolar rotation in different groups

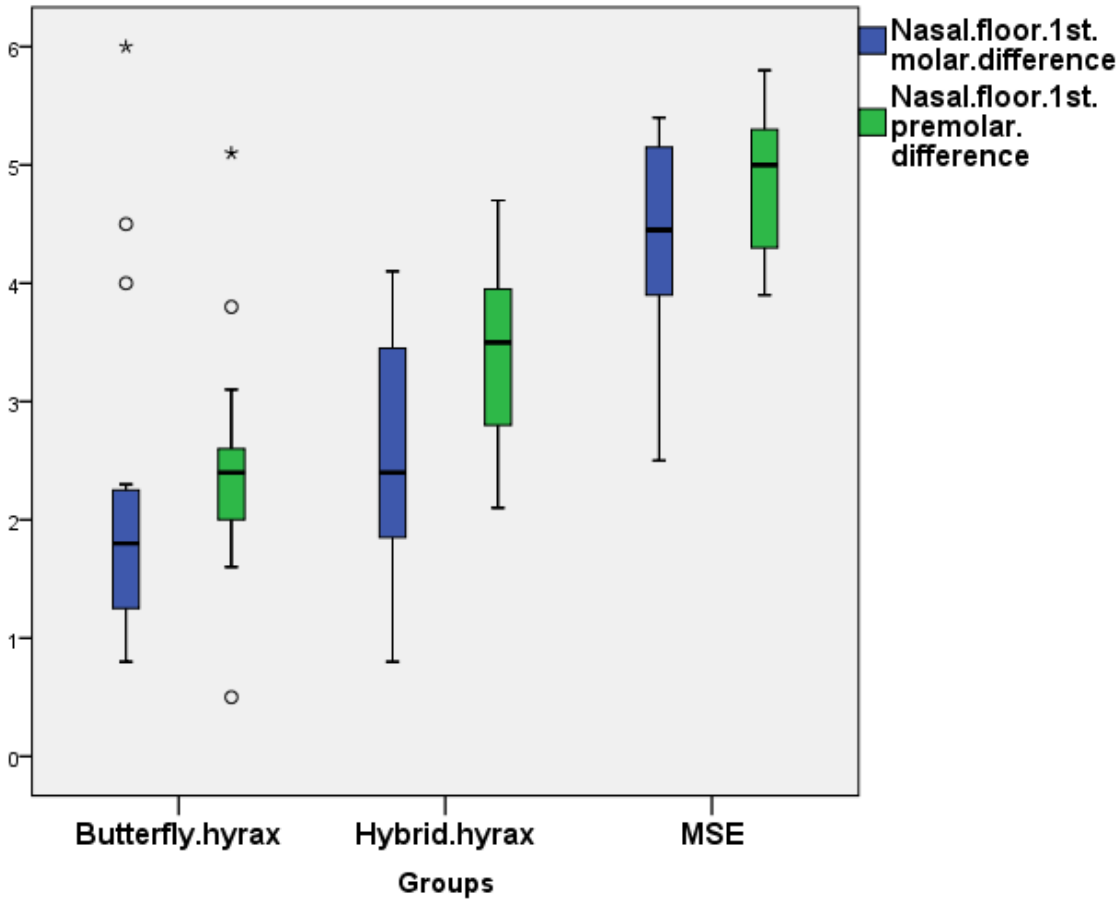


Fig. (13) Box plot illustrating value of difference in nasal floor difference in different groups

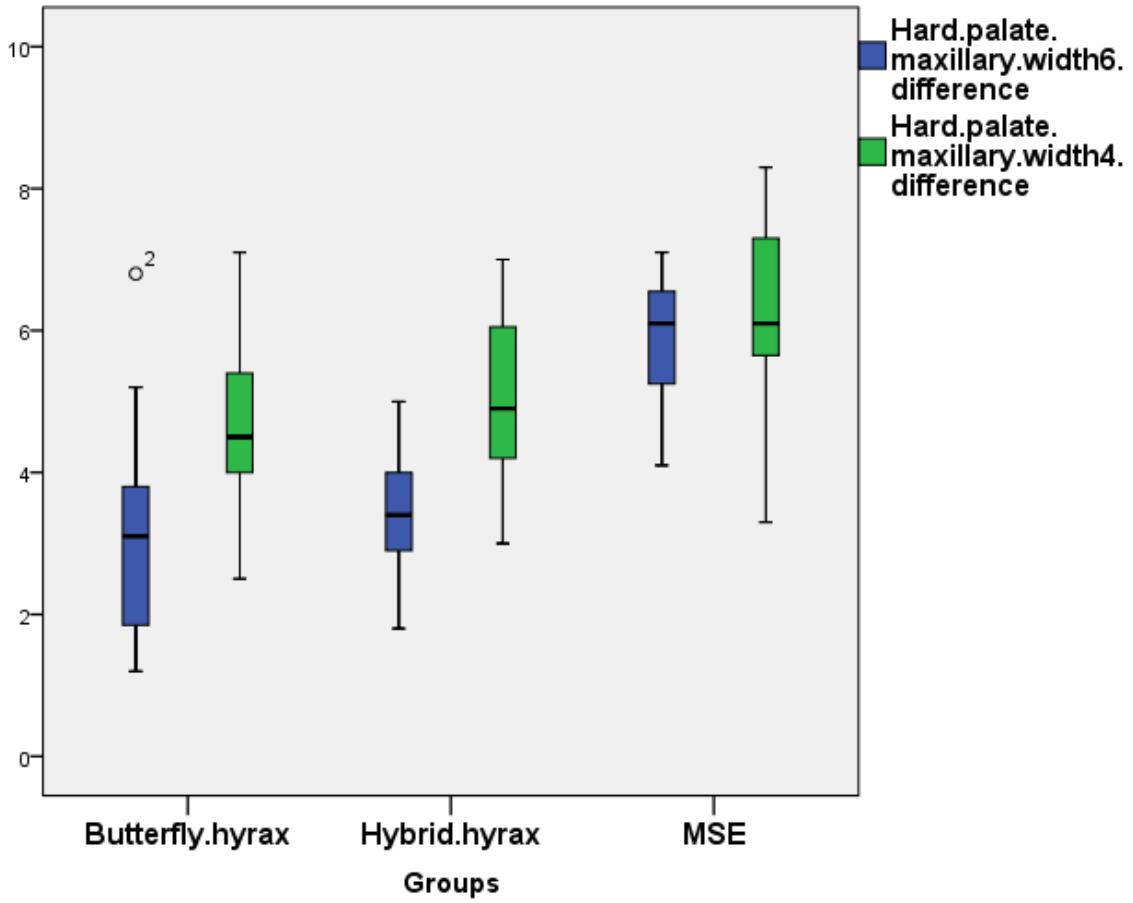


Fig. (14) Box plot illustrating value of difference in hard palate maxillary molar and premolar in different groups

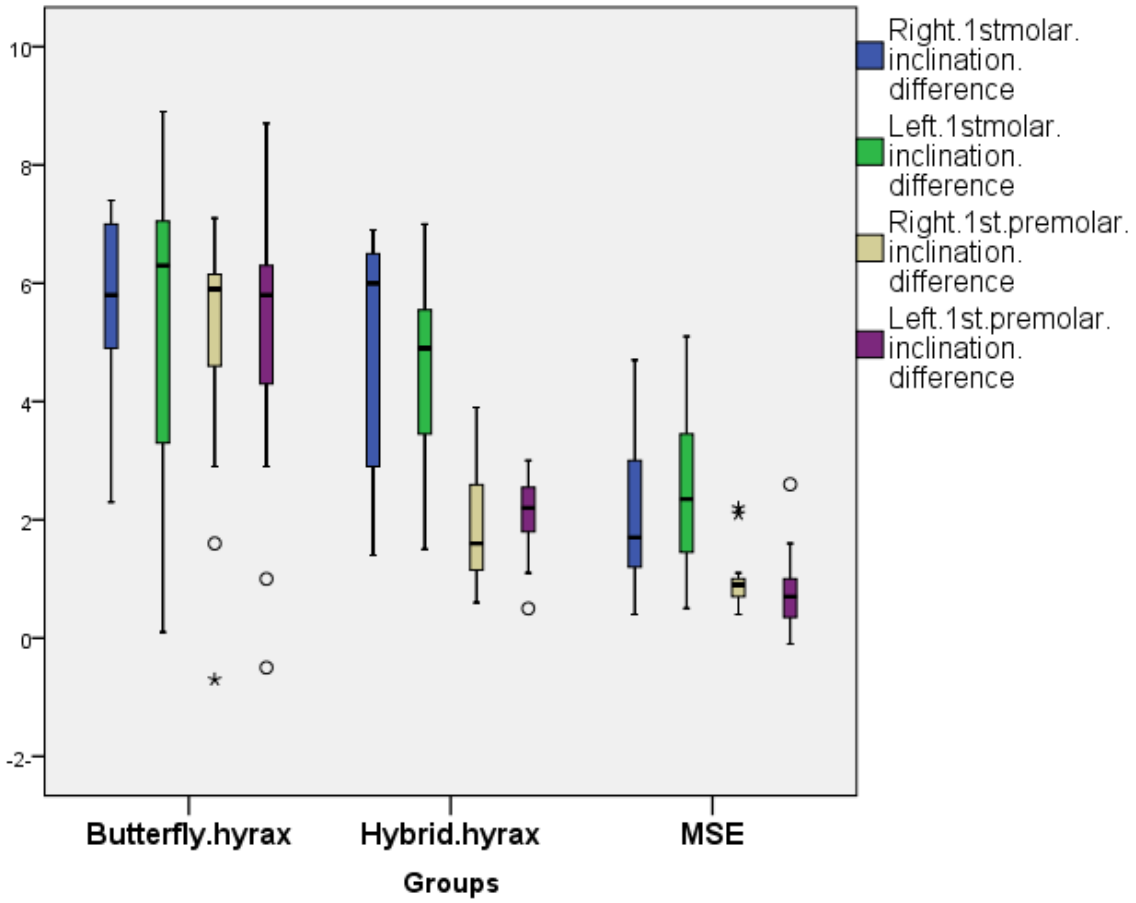


Fig. (15) Box plot illustrating value of difference in molar and premolar inclination in different groups

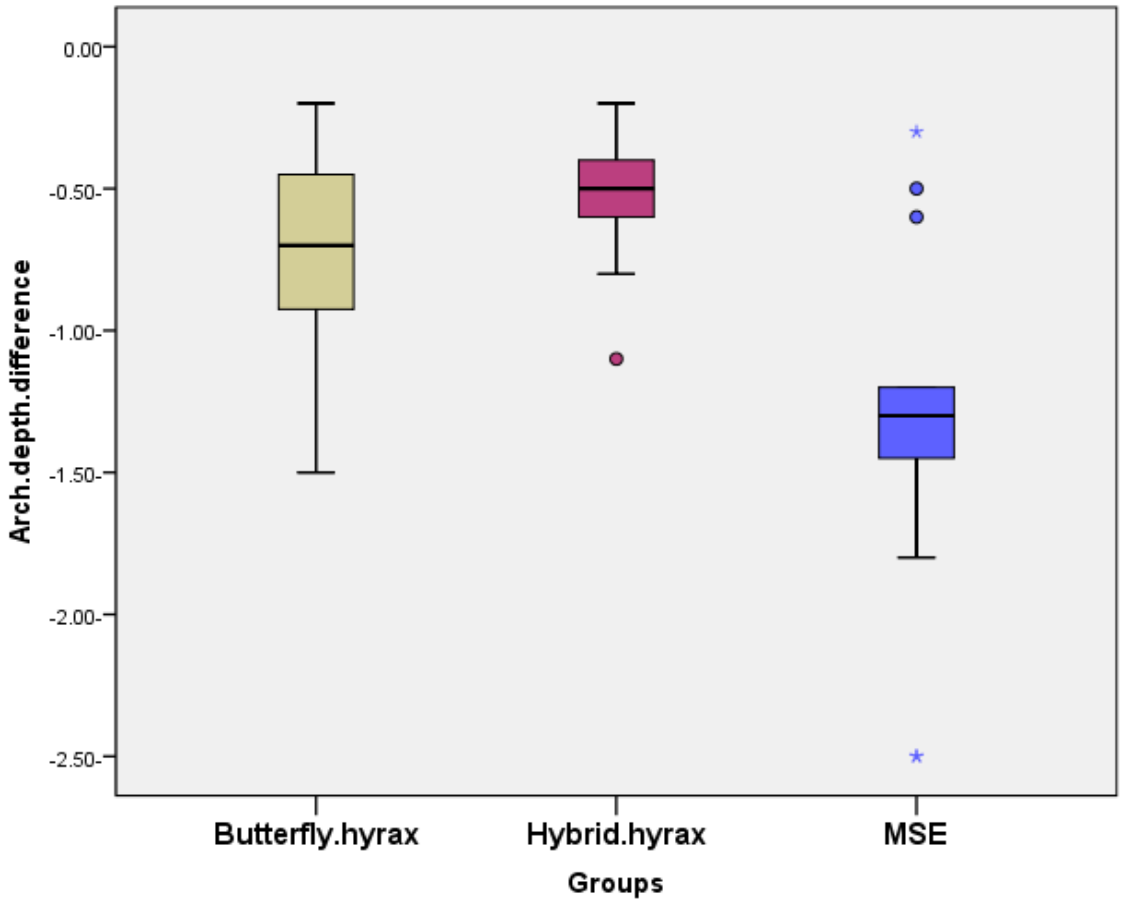


Fig. (16) Box plot illustrating value of difference in arch depth in different groups

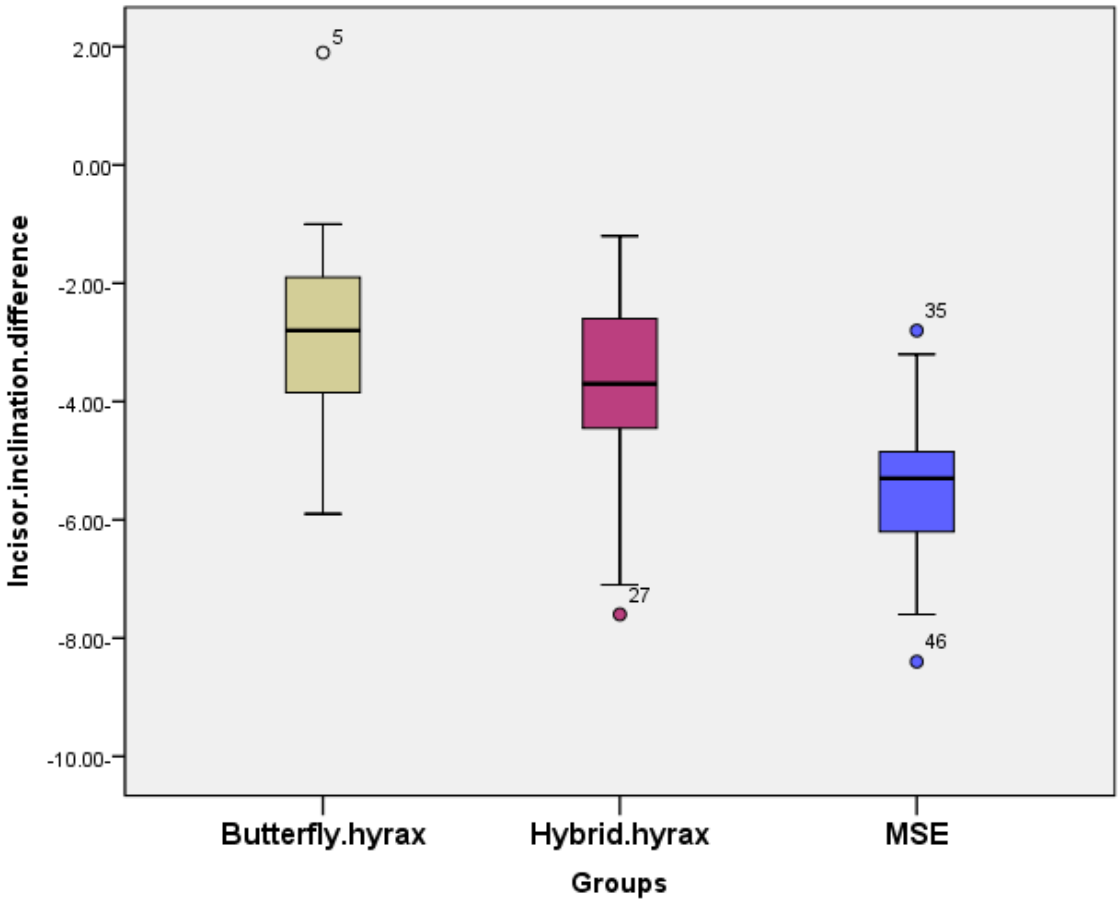


Fig. (17) Box plot illustrating value of difference in incisor inclination in different groups

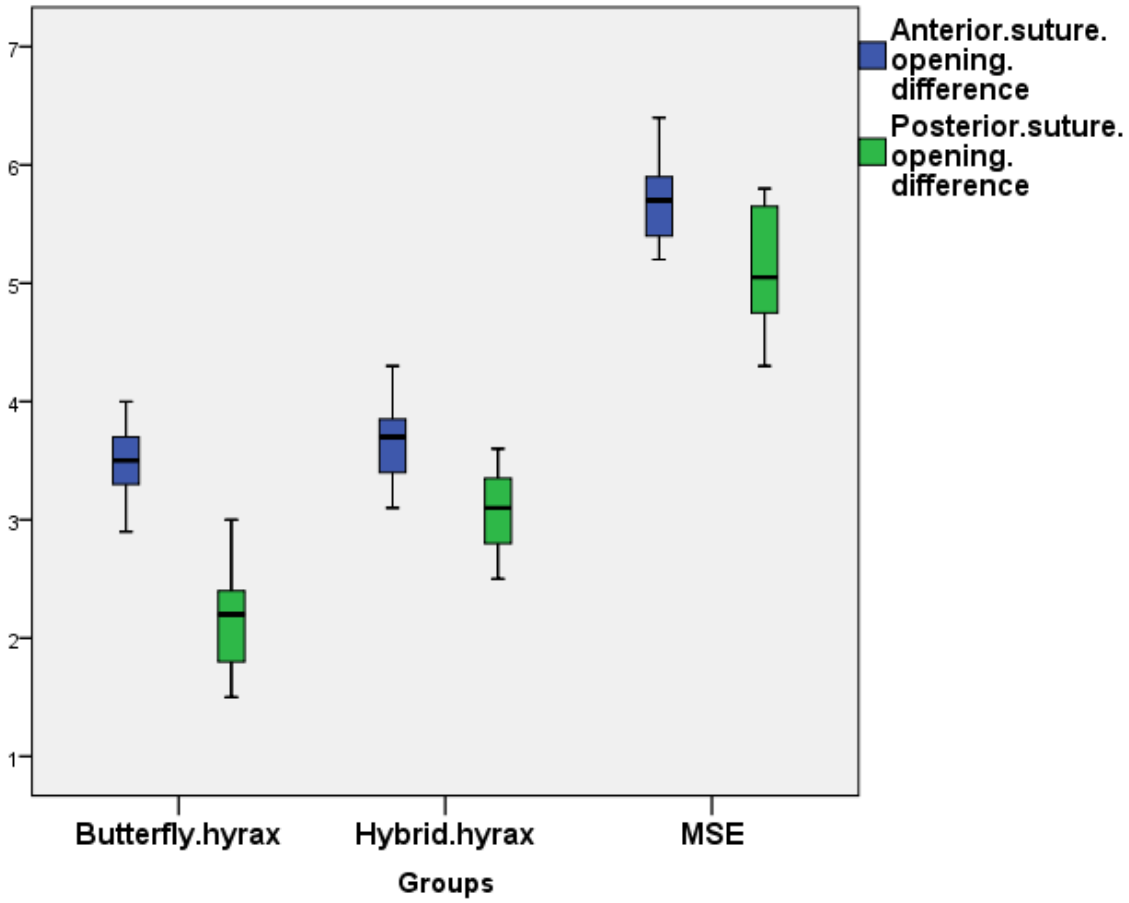


Fig. (18) Box plot illustrating value of difference in anterior and posterior suture opening in different groups