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ORIGINAL ARTICLE

Occlusal bite force changes during fixed orthodontic treatment in patients with different vertical facial morphology

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1. Introduction

In orthodontics, treatment planning and treatment progress requires in depth knowledge and understanding of the masticatory muscles and their relationship to different facial morphology. Occlusal Bite Force (OBF) is used to assess the functional status of the masticatory mechanism (Bakke, 2006). There are several factors influencing the occlusal bite force. They include age, gender, cranio-facial morphology, periodontium, temporomandibular joint disorders and dental status (Koc et al., 2010). Long-faced individuals exhibits smaller values of bite force and short-faced type of craniofacial morphology has been associated with stronger bite force (Abu Alhaija et al., 2010). Bite force reduces significantly through age, particularly in women (Shinogaya et al., 2001). Weak periodontium may reduce the threshold value of the mechanoreceptors causing changes in biting force (Morita et al., 2003). The greater bite force in the posterior dental arch depends on the larger occlusal table, contact area and the number of teeth loaded during the biting action (Babic et al., 2002).

Maximum Voluntary Bite Force (MVBF) and malocclusion has a strong relationship. In earlier reports the decrease in MVBF due to malocclusion was well documented (English et al., 2002). Greater bite force found in individuals with normal occlusion, followed by Classes I, II and III malocclusion respectively (Araújo et al., 2014). Reduction in maximum bite force and number of occlusal contacts was reported in children having unilateral posterior cross bite in comparison with those possessing ideal occlusion (Sonnesen and Bakke, 2007). It is reported that bite force values decreased during the initial period of active orthodontic treatment but, with time, recovered to pretreatment levels (Sawsan et al., 2012). It was also noted that occlusal bite force increased after orthodontic treatment (Winocur et al., 2007). Pain and discomfort due to orthodontic appliances and changing occlusal relationships during orthodontic treatment produces reduction in occlusal bite force (Yawaka et al., 2003). Assessment of bite force during orthodontic treatment gives a clue to the orthodontist regarding the type of mechanics to be used. It is also helpful in diagnosing any interferences in the stomatognathic system during orthodontic treatment (Sathyanarayana et al., 2012). Only few studies have addressed the issues of occlusal bite force change during fixed appliance orthodontic treatment (Sawsan et al., 2012; Yawaka et al., 2003). While changes in bite forces have been shown to occur during routine orthodontic treatment, and that bite forces vary with varying facial patterns,

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there is no clarity whether the change in bite force during orthodontic treatment is same for all patients or if it differs with different types of facial patterns. Hence this study assess the changes in occlusal bite force during the first 6 months of fixed appliance orthodontic treatment and the time taken to reach ideal bite force in patients with different vertical facial morphology.

2. Materials and methods

The ethical clearance from the Institutional ethics committee of Government Dental College and Hospital was obtained (Ref. No.: 0420/DE/2016). Outpatients undergoing orthodontic treatment at Department of Orthodontics and Dentofacial Orthopaedics, Government Dental College and Hospital, were screened for this cross sectional study by consecutive sampling method.

2.1. Study population and characteristics

30 patients (11 males and 19 females) who satisfies the following inclusion criterion formed the study group (A) were included in this study. The inclusion criteria are: 1. Healthy individuals with no missing teeth except the third molar, 2. Age group of 14–20 years, 3. Both male and female sex, 4. Mild to moderate crowding (1–6 mm of discrepancy), 5. Mild to moderate spacing of less than 10 mm, 6. Class I Skeletal Base (ANB = 2–4°), 7. No H/o prior orthodontic treatment, 8. No posterior/anterior crossbite, 9. No temporomandibular joint problems, 10. No systemic disorders and any other craniofacial anomalies, 11. No periodontal disease, restorations or large carious lesions.

The study group (A) was categorized according to their facial types (based on cephalometric values FMA- (average value- 25–28°), Go Gn –SN - (average value-32–35°) into three sub groups namely A_1- Hypodivergent individual (n = 10, 4 males and 6 females), A_2- Normodivergent individual (n = 10, 3males and 7 females) and A_3- Hyperdivergent individual (n = 10, 4 males and 6 females). The procedure involved in the study was explained and written consent was obtained from all subjects before beginning the study. All the pretreatment records were obtained and the orthodontic treatment plan for the study group was established. Orthodontic treatment was started with 0.022 slot MBT prescription, non-extraction treatment and banding of the first and second molars in both upper and lower arches was done. The following sequence of change of arch wires were done during every visit for all the study group: 0.014 Ni-Ti, 0.016″ NiTi, 0.016″ SS, 0.017 × 0.025 Ni-Ti, 0.019 × 0.025 NiTi, 0.019 × 0.025 SS.

2.2. Bite force measurement

Occlusal Bite Force (OBF) was recorded for all the study groups (A_1, A_2 and A_3) at the following time intervals: T_0: Just prior to orthodontic elastic separator insertion, T_1: A week after the placement of orthodontic appliances and T_2–T_7: the bite force was recorded at the end of every month from the first month before the scheduled arch wire change for that visit. OBF was measured using a ‘‘Strain gauge transducer- Digital bite force meter” (Hariom Electronics, Gujarat, India). This gadget uses electronic technology encompass a biting plate and body. The gadget presents a scale which measures force in Newtons (N). The thickness of biting forks of the strain gauge transducer were reduced and is covered with the polymeric material to prevent any damage to the tooth structure. During measurement, biting forks were encased in a disposable latex finger cot to safeguard the participants from cross contamination. The individuals were seated in an upright position, looking forward without back support with the Frankfort Horizontal plane parallel to the floor. The load cell unit was placed parallel to the occlusal plane. OBF was measured bilaterally in the first permanent molar region. Each participant was directed to bite on the biting forks as hard as possible without moving their head. The average maximum OBF of the right and left sides is recorded as the occlusal bite force (OBF) for the patient is included in this analysis.

2.3. Statistical analysis

Statistical analysis was carried out using the Statistical Package for the Social Sciences computer software (SPSS 21.0, SPSS Inc., IL, USA). Shapiro-Wilks test was carried out to assess the normality of OBF data collected during the study. The repeated measures analysis of variance (within-subjects ANOVA) test with a Greenhouse-Geisser correction and Bonferroni post-hoc comparison were conducted to examine and define the differences in means of OBF measured at the different time intervals before and during orthodontic treatment. The statistical analyses were carried out at $p \leq 0.05$ level of significance.

3. Result

The mean OBF, standard deviation and percentages of OBF loss and recovery during orthodontic treatment at different time intervals for hypodivergent group (A_1), normodivergent group (A_2) and hyperdivergent group (A_3) are shown in Tables 1, 2 and 3 respectively. A repeated measures ANOVA with a Greenhouse-Geisser correction determined the mean scores for OBF in study group (A_1) were statistically significant (F (3.133, 28.196) = 75.335, $p < 0.0005$). Post hoc tests using the Bonferroni correction revealed that the study group A_1 shows no significant difference in OBF between time points T_1 and T_2 (p = 0.301), T_2 and T_3 (p = 0.264), T_3 and T_4 (p = 0.232), T_4 and T_5 (p = 0.619), T_5 and T_6 (p = 0.063), and T_6 and T_7 (p = 0.072). The mean scores for OBF in study group (A_2) were statistically significant (F (2.352, 21.164) = 132.064, $p < 0.0005$). Post hoc tests using the Bonferroni correction revealed that in the study group A_2 there was no significant difference in OBF between time T_0 and T_7 ($p = 0.307$), rest of the time interval shows significant difference at $p < 0.005$ level.

The mean scores for OBF in study group (A_3) were statistically significant (F (2.370, 21.329) = 181.543, $p < 0.0005$). Post hoc tests using the Bonferroni correction revealed that in the study group A_3 there was no significant difference in OBF between time T_0 and T_6 (p = 0.396), T_0 and T_7 (p = 1.00) and T_2 and T_3 (p = 0.340). The patterns of OBF changes during orthodontic treatment at different time intervals (T_0–T_7) for hypodivergent (A_1), Normodivergent (A_2) and hyperdivergent (A_3) treatment group are shown in Fig. 1. Percentage (%) Occlusal Bite Force loss and recovery

Table 1 OBF (N) at different intervals in hypodivergent group A_1 (n = 10).

Time interval	Study group (A_1) OBF (N) (Mean ± SD)	Loss (%)	Recovery (%)
Before (T_0)	469.40 ± 69.23*	–	–
1st week (T_1)	191.67 ± 62.89*	59.17	–
1st month (T_2)	230.60 ± 60.94	50.87	14.02
2nd month (T_3)	275.27 ± 42.42	41.36	30.10
3rd month (T_4)	306.60 ± 52.20	34.68	41.38
4th month (T_5)	320.60 ± 48.07	31.70	46.42
5th month (T_6)	343.90 ± 42.77	26.74	54.81
6th month (T_7)	389.20 ± 38.59	17.09	71.12

*denotes significance $p < 0.05$ level.

Table 2 OBF (N) at different intervals in normodivergent group A_2 (n = 10).

Time interval	Study group (A_2) OBF (N) (Mean ± SD)	Loss (%)	Recovery (%)
Before (T_0)	435.93 ± 48.47	–	–
1st week (T_1)	160.03 ± 28.81*	63.29	–
1st month (T_2)	227.53 ± 27.39*	47.81	24.47
2nd month (T_3)	282.13 ± 20.10*	35.28	44.26
3rd month (T_4)	321.93 ± 25.41*	26.15	58.68
4th month (T_5)	349.93 ± 24.67*	19.73	68.83
5th month (T_6)	378.20 ± 23.67*	13.24	79.07
6th month (T_7)	400.40 ± 22.30	8.15	87.12

*denotes significance $p < 0.05$ level.

Table 3 OBF (N) at different intervals in hyperdivergent group A_3 (n = 10).

Time interval	Study group (A_3) OBF (N) (Mean ± SD)	Loss (%)	Recovery (%)
Before (T_0)	348.87 ± 28.16	–	–
1st week (T_1)	120.03 ± 44.09*	65.59	–
1st month (T_2)	208.70 ± 26.95	40.18	38.75
2nd month (T_3)	241.13 ± 17.58	30.88	52.92
3rd month (T_4)	274.53 ± 28.32*	21.31	67.52
4th month (T_5)	270.70 ± 17.11*	22.41	65.84
5th month (T_6)	325.70 ± 19.03	6.64	89.88
6th month (T_7)	354.77 ± 25.50	−1.69	102.58

*denotes significance $p < 0.05$ level.

at different time intervals in A_1, A_2 and A_3 study group patients, before and during fixed orthodontic treatment are represented in Fig. 2. The bite force recovery percentage was high in all study groups at time T_7. However the recovery percentage is greater for hyperdivergent study group (A_3) of about 102.52%, 87.12% for normodivergent study group (A_2) and 71.12% for hypodivergent study group (A_1).

4. Discussion

Improvement of functional efficiency is one of the aim of orthodontic treatment. Biting efficiency is an important aspect of oral functions, it may deliberate by occlusal bite force measurements. Occlusal bite force is the most important parameter in assessing the biting efficiency which is likely to change during orthodontic treatment. It is well known that patients undergoing orthodontic therapy experience a loss of masticatory efficiency, a phenomenon partially due to a reduction in the patient's ability to exert occlusive force. The present study has measured OBF before and during treatment showed variations in patient with different vertical facial morphology. Earlier study of Sawsan et al. (2012) also agrees that OBF has been shown to differ in patients with different vertical facial morphological characteristics.

4.1. Factors affecting bite force

Among the study groups hyperdivergent facial morphology exhibited lower OBF and hypodivergent facial morphology exhibited higher OBF when compared to normodivergent facial morphology at T_0. This confirms the finding that cranio-facial morphology with short-faced individuals exhibit higher OBF and the long-faced type has smaller value of OBF (Abu Alhaija et al., 2010). Subjects aged 15 years and above were recruited as evidence suggested that OBF increases with age which stabilises after the age of 14 years. With physiological aging process the bite forces start declining from about 50 years of age (Proffit et al., 2014). The present study employed a strain gauge transducer with a biting element encased in polymeric covering which provides a comfortable surface for maximum bite force. Tortopidis et al. (1998) have used acrylic capping in contact with the metal faces of the strain-gauge transducers to depreciate the risk of fractures in the enamel when biting hard on the transducer.

4.2. OBF and fixed orthodontic treatment

Intensities of pressure, tension, pain and sensitivity to teeth is increased in patients wearing fixed appliances as compared with those treated with removable orthodontic treatment (Stewart et al., 1997). Hence the changes in OBF measured during this study were considered to be the result of orthodontic treatment. A large reduction in OBF (50%) occurred at the end of the first week following the placement of separators. It is a known fact that placing orthodontic separators (brass wire, elastomerics, spring type steel separators) emanates a painful experience for almost all patients (Abdullah Aldrees, 2015). An electromyographic (EMG) study, conducted to determine the motor and sensory changes associated with placement of separators, showed reduced pressure pain threshold as well as motor output in masticatory muscles (Goldreich et al., 1994). The reduction in OBF observed in the present study may be due to changes in occlusal contacts during treatment, as it was reported that occlusal contacts determine 10–20% of variation of maximum bite force in adults (Bakke, 2006). Bite force in the study group remained

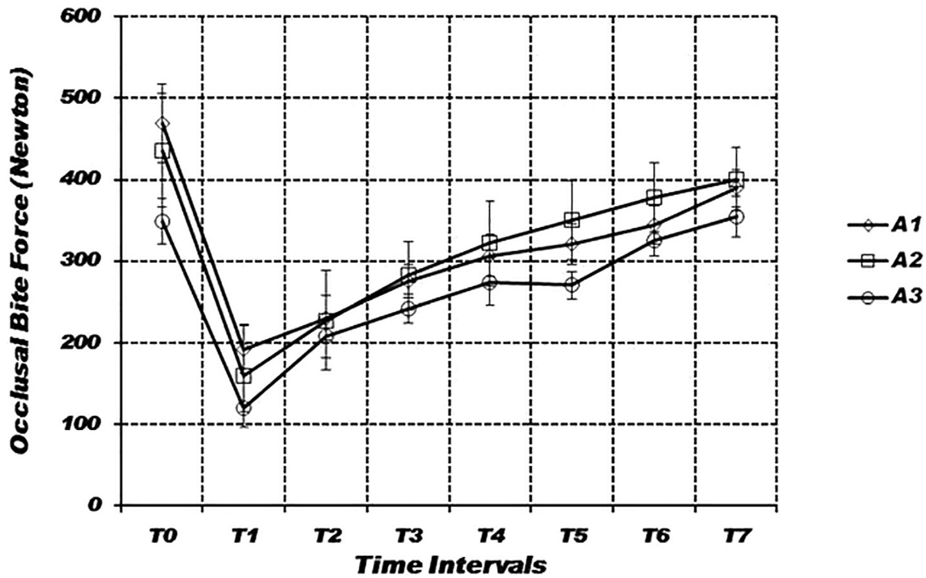

Fig. 1 Changes in OBF (N) at different intervals in A_1, A_2 and A_3 study groups.

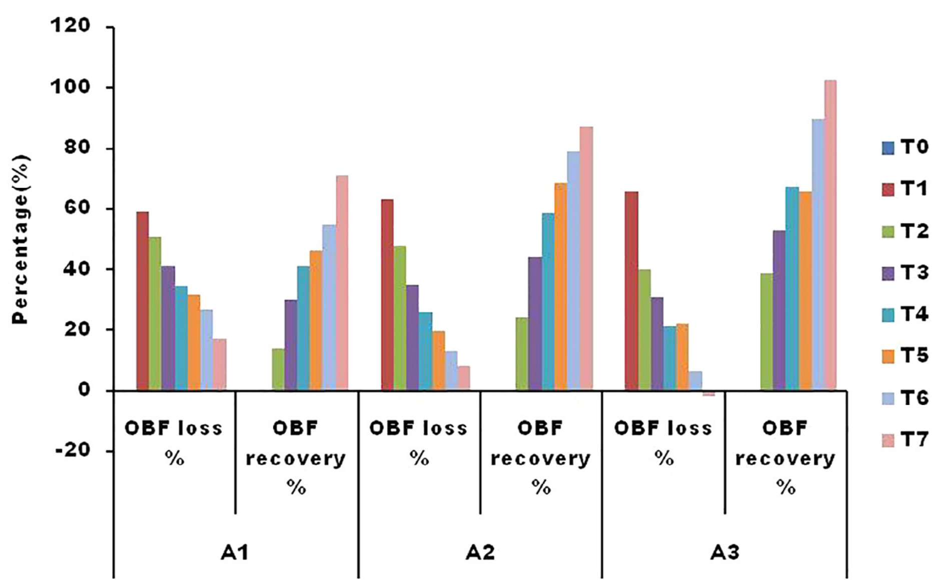

Fig. 2 Percentage (%) occlusal bite force loss and recovery in A_1, A_2 and A_3 groups.

significantly reduced during the first week and in the first month. This could be attributed to a greater deflection of the initial archwires in order to obtain bracket engagement (Krishnan, 2007). Since the same size archwire was utilized for all patients, and the early objectives of leveling are the same, physiological explanations for the reduction of bite force during these initial stages of orthodontic treatment are rather subjective in nature.

4.3. Changes in OBF during aligning and leveling stage

In the present study OBF shows a tendency to return to pretreatment level in treatment group at the completion of aligning and leveling stage of fixed orthodontic treatment. This may be due to increase in occlusal contact area and leveling the curve of spee. This is in accordance to the previous studies, that leveling the curve of spee increases the occlusal contact area of posterior teeth (De Praeter and Dermaut, 2002). OBF shows a tendency to return to pretreatment (even beyond the pretreatment level although is statistically insignificant) earlier in hyperdivergent treatment group when compared to normodivergent and hypodivergent treatment group. This observation could be attributed to the delay in the time interval during the alignment and leveling stage in hypodivergent vertical facial morphology. There is a significant correlation between bite force, muscle thicknesses and facial morphology (Maspero et al., 2015). In this view, Farella et al. (2003) have stated that masseter muscles are thicker in short face type of craniofacial morphology than in normal or long-faced individuals. Hypodivergent individuals with the thicker masseter muscle takes a longer time for adaptation during fixed appliance therapy. Muscular adaptation takes place within the first three months followed by a substantial reduction in muscular changes within the next three months after active orthodontic treatment (Varga et al., 2017). Al-Khateeb et al. (2015) measured OBF change after orthodontic treatment with activator reported a significant reduction in bite force, which is considered to be due to the changes in muscular activity when wearing the functional appliance, also confirms the findings of this research.

4.4. Significance of the study

Understanding the range of bite force changes during orthodontic treatment will enable us to understand the changes of the stomatognathic system during treatment. This is likely to help us identify the marked deviations and take steps to alleviate causative agents and thereby improve quality of mastication even during orthodontic treatment. Further extended research is required to confirm these findings with the larger sample size, since there are various other factors affecting bite force especially during orthodontic treatment (i.e. number of occlusal contacts and gender etc.)

5. Conclusion

In conclusion, the Occlusal bite force (OBF) is least, average and higher in hyperdivergent, normodivergent and hypodivergent individuals respectively. The OBF altered during the treatment is due to fixed orthodontics. OBF is reduced to 50% of the pretreatment level during the first week of fixed orthodontic treatment. After aligning and leveling stage, the OBF reaches the baseline level in hyperdivergent treatment group, while it reaches close to pretreatment level in hypodivergent and normodivergent treatment groups.

Ethical approval

Ethical approval for the present research study was obtained from the Institutional ethics committee of Tamil Nadu Government Dental College and Hospital, Chennai on august 1st 2016. (Ref No: 0420/DE/2016).

Conflict of interest

The authors declared that there is no conflict of interest.

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