Comparative Evaluation of Occlusal Bite Force in Relation to the Muscle Activity in the Mixed Dentition Children of Age Group 9–12 Years: A T-scan Analysis

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ABSTRACT

Aim and objective: Compare and evaluate the muscle activity and the occlusal force between the mixed dentition boys and girls of 9–12 years.

Materials and methods: The study included 15 boys and 15 girls. The occlusal force and activity of the masseter and temporalis muscle were measured with a T-scan device using a sensor, a module to transmit the signals to a computer and the complete data of the bite force and muscle activity with the EMG recordings and data were collected and evaluated.

Results: Relative occlusal force in the primary and permanent molars between the boys and girls showed no significant difference on the left side compared to the right. The electromyography values of masseter and temporalis in boys and girls showed a significant difference in which (TAR and MMR), (TAR and MML), (TAL and MMR), and (TAL and MML) are significant. The overall paired sample statistics showed higher muscle activity in masseter.

Conclusion: T-scan analysis has proved to be a dependable method for the evaluation of occlusal bite force with the muscle activity interpretation using EMG. This study concluded that there is a difference in the occlusal pattern and muscle activity in the mixed dentition that showed the maximum force was on the permanent molars and the symmetry of EMGs activity in children was on the right masseter comparatively with higher bite values in boys compared to girls.

Clinical significance: T-scan is a computerized analysis system that helps in the proper assessment of the patient's occlusion and assists in the proper treatment planning and diagnosis accurately without much effort.

Keywords: EMG, Mixed dentition, Occlusal bite force, T-scan.

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INTRODUCTION

The occlusal bite force is the key indicator for masticatory performance and it is defined as the forces exercised by the muscles of mastication in normal occlusion.[1] These forces guide the function of the masticatory system resulting in the elevation of the muscles altered by the craniofacial biomechanics.[2] It helps in coordinating the muscles, bones, and teeth of the masticatory system and is an important indicator of stomatognathic deformities.[3]

The mixed dentition stage begins when the mandibular first permanent molars or incisors erupt. It is an interim period between both the dentition and continues till all the primary teeth are restored with the permanent.[4] Studies have been reported that the growth and development period in any dentition includes environmental factors, nutrition, cultural variations, systemic variations, and individual differences.[5]

The purpose of one's bite force levels has been extensively used to follow the activity of the muscles.[6] Measuring the masticatory force of individuals helps in understanding "the biomechanical principles of masticatory muscles". Also, the masticatory force is important for the diagnosis and treatment of dysfunction.[7] Studies showed higher muscular activity in masseter in males and temporalis in females during clenching.[8]

The contact between the teeth is referred to as occlusion. The indicators used for occlusion can be broadly divided as qualitative (articulating paper, articulating silk, articulating film, metallic shim stock film, high spot indicator) and quantitative (T-scan occlusal analysis system, virtual dental patient). There is no scientific

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correlation between the depth of the color and the mark using articulating paper and other qualitative methods because it cannot calculate the occlusal load.[8] To resolve this in 1987 Maness et al. introduced a new computerized device (T-scan system; Sentek Crop, Boston, MA, USA) which precisely and dynamically records the time, force, and area of occlusal contacts and is used as a precise

and simple clinical diagnostic device that detects the bite force using paper-thin disposable sensors.[9] Later in 2006, two different dental technologies were bonded, i.e., T-scan II (Tekscan Inc., S. Boston, MA, USA) for windows and BioEMG II (Bioresearch, Inc., Milwaukee, WI, USA) for windows which synchronously recorded the electromyography levels and occlusal bite force.[10]

Therefore, the recent advances to examine occlusal contacts and muscle function with computer technologies have paved way for the dentists. Studies have been done to compare the masticatory force and time using electromyography with T-scan in adults. Still, there remains a need to understand the occlusal bite force and muscle activity, in the mixed dentition age group. Hence, the current study was done to compare and evaluate the muscle activity in the mixed dentition age group of 9–12 years.

Materials and Methods

Patient Selection

The protocol of the study was accepted by the Institutional Ethical and Review Committee. A sum of 30 (15 boys and 15 girls) took part in the study with the age range of 9–12 years. The inclusion criteria included (1) Cooperative children, (2) Children with sound healthy dentition, (3) Children with no history of orthodontic treatment, (4) Children with no parafunctional habits, (5) Children with normal overjet and overbite, (6) Children with minor crowding or spacing, (7) Children with normal oral tissue, and (8) Children with permanent molars, whereas the exclusion criteria include (1) Children with TMJ disturbances, (2) Medically compromised children, (3) Children with apparent facial asymmetry that could affect the recordings, (4) Children with orthodontic treatment, (5) Children with anterior or posterior crossbites or open bite, and (6) Children with restorations. Thirty children who met the inclusion criteria were included in the study.

Occlusal Bite Force

To record the occlusal bite force, each child was made to sit comfortably with their head adjusted keeping the Frankfurt horizontal plane exactly parallel to the floor and body upright. All the participants of the study underwent surface electromyography (SEMG) recording with an 8-Channel BioEMG III BioPAK Measurement system Electromyograph (Bioresearch, Inc., Milwaukee, WI, USA) (Fig. 1). Before the recording, the area on the face where the

EMG electrodes were to be placed was cleaned with spirit, EMG electrodes which are self-adhesive were placed in the masseter and temporalis area with the tip of each electrode aligned to the muscle fibers. In a single session, the measurements of the occlusal bite force were taken for each child, using a portable T-scan device. Before starting the test, each child was asked to prepare their best occlusal bite by biting onto the digital occlusal sensor (T-scan Novus). The digital occlusal scans were taken using a digital occlusal sensor and the data was thus recorded resulting in the distribution of occlusal force and this information was presented in 2D and 3D graphics by the Tekscan software. For each patient, a new single sensor sheet was used to obtain the scans (Fig. 2). The patient was instructed to bite with maximum biting force, making sure the teeth occluded normally and released. The sensor was inserted in such a way that the patient's mouth was aligned centrally with the midline of the upper incisor and the patient was asked to bite with maximum intercuspation. This was repeated three times with an interval between each recording. The right value of the three occlusal bite forces was listed as the maximum occlusal bite force. The mean values were obtained and statistically analyzed.

Results

A total of 30 (15 boys and 15 girls) participated in the study with the age range of 9–12 years. Relative occlusal force and sEMG activity was calculated. This demonstrates the age and sex cross-tabulation of the mixed dentition age group which included 30 (15 boys and 15 girls) (Table 1). The statistical analysis was done using Mann–Whitney test which compared the relative occlusal force of the anterior and posterior right and left region of the jaw and found that no significant difference was seen between boys and girls. The data were expressed as mean ± SD (Table 2). Comparison of the mean and standard deviation of the relative occlusal force in the

Fig. 1: Participant of the T-scan study with BioEMG III BioPAK Measurement system connected with EMG electrodes
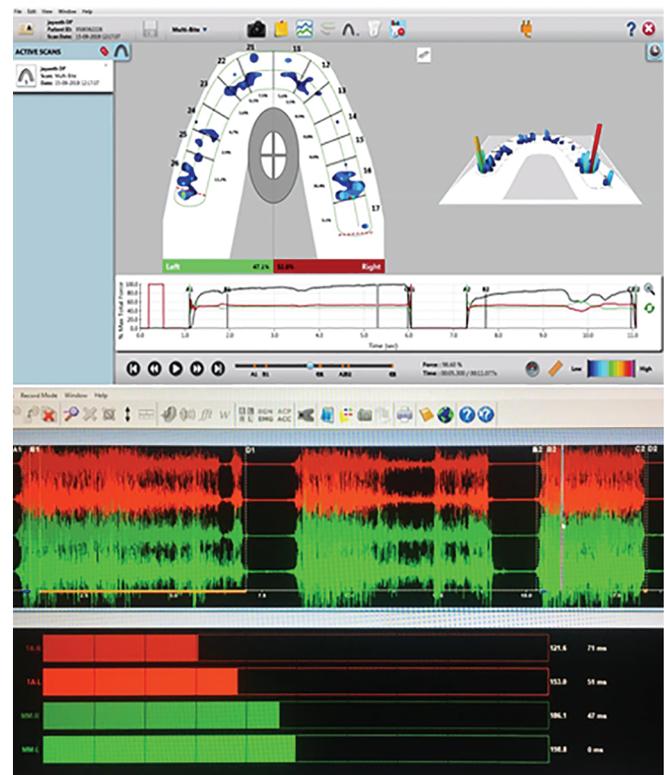

Fig. 2: Participants occlusal bite force and EMG recordings

primary and permanent molars between boys and girls. The mean value was seen to be higher on the left permanent molar compared to the right molar in girls (Table 3). Surface EMG recording from the left temporalis anterior (TAL), right temporalis anterior (TAR), and left masseter muscle (MML) and right masseter muscle (MMR) demonstrated a statistically significant difference in the voltage of the muscles, whereas no significant difference was seen in the right masseter muscle (MMR) ($p = 0.146$). According to gender, the sEMG value showed a significant difference in boys and girls (Table 4). Paired sample statistics with a mean and standard deviation of the

relative occlusal force on AL, AR, PL, and PR (boys and girls) was done using Wilcoxon signed-rank test (Table 5). The paired sample statistics showed a significant difference in the relative occlusal force in anterior left and posterior right respectively (Table 6). Paired sample statistics of EMG boys and girls showed a significant difference in Pair 2 (TAR and MMR), Pair 3 (TAR and MML), Pair 4 (TAL and MMR), and Pair 5 (TAL and MML). The overall paired sample statistics showed higher muscle activity in masseter (Table 7).

A positive comparison was seen between muscle activity and occlusal force in both boys and girls of the mixed dentition age group (Table 8).

DISCUSSION

Occlusal bite force indicates the state of functional mastication and loading of teeth which often leads to jaw elevations with the help of muscles that are determined by the central nervous system and are retrogressed from the muscle spindles, mechanoreceptors, and nociceptors which leads to alteration of craniomandibular biomechanics. It is generally said that a superior masticatory system leads to a stronger bite force.[1] Studies proposed by Rentes et al.; Kamegai et al.; Sonnesen and Bakke have shown that the

Table 1: Age and sex cross-tabulation of the mixed dentition age group

	Age	Sex Boys	Girls	Total
Age	9	3	3	6
	10	6	5	11
	11	2	5	7
	12	4	2	6
Total	Total	15	15	30

p value < 0.05, Statistically significant

Table 2: Comparison of the mean and standard deviation for the relative occlusal force between the male and female using Mann–Whitney test

	Sex	N	Mean	Std. deviation	Mean rank	Mean difference	Mann–Whitney U	p value
Relative occlusal force–AL	Boys	15	7.57	10.63	17.17	−1.763	87.500	0.299
	Girls	15	9.34	13.73	13.83			
Relative occlusal force–AR	Boys	15	11.14	9.32	16.60	−0.028	96.000	0.492
	Girls	15	11.17	13.52	14.40			
Relative occlusal force–PL	Boys	15	37.14	14.76	13.83	−4.875	87.500	0.300
	Girls	15	42.02	20.03	17.17			
Relative occlusal force–PR	Boys	15	43.74	18.78	17.10	7.973	88.500	0.319
	Girls	15	35.77	20.01	13.90			

Table 3: Comparison of the mean and standard deviation of the relative occlusal force in the primary and permanent molars between boys and girls using Mann–Whitney test

	Sex	N	Mean	Std. deviation	Mean rank	Mean difference	Mann–Whitney U	p value
Relative occlusal force–T55,85	Boys	13	4.88	5.81	11.04	−7.530	52.500	0.060
	Girls	14	12.41	9.83	16.75			
Relative occlusal force–T16,46	Boys	15	26.83	13.08	18.03	8.093	74.500	0.115
	Girls	15	18.74	13.13	12.97			
Relative occlusal force–T65,75	Boys	15	13.76	10.56	14.70	−2.180	100.000	0.618
	Girls	15	15.94	14.00	16.30			
Relative occlusal force - T26,36	Boys	15	13.47	15.34	12.33	−13.873	65.000	0.048
	Girls	15	27.34	17.26	18.67			

Table 4: EMG values for right and left masseter and temporalis in boys and girls using Mann–Whitney test

	Sex	N	Mean	Std. deviation	Mean rank	Mean difference	Mann–Whitney U	p value
Electromyography–TAR	Boys	15	109.52	44.86	18.77	34.029	63.500	0.042
	Girls	15	75.49	45.70	12.23			
Electromyography–TAL	Boys	15	131.52	41.90	19.33	47.387	55.000	0.017
	Girls	15	84.13	51.11	11.67			
Electromyography–MMR	Boys	15	187.46	80.62	17.83	45.696	77.500	0.146
	Girls	15	141.76	63.47	13.17			
Electromyography–MML	Boys	15	238.03	98.97	20.00	94.855	45.000	0.005
	Girls	15	143.17	59.69	11.00			

Table 5: Paired sample statistics with a mean and standard deviation of the relative occlusal force on AL, AR, PL, and PR (boys and girls) using Wilcoxon signed-rank test

		N	Mean	Std. deviation	Mean difference	Z	p value
Pair 1	Relative occlusal force–AL	30	8.45	12.10	−2.699	−1.389	0.165
	Relative occlusal force–AR	30	11.15	11.41			
Pair 2	Relative occlusal force–AL	30	8.45	12.10	−31.123	−3.960	0.000
	Relative occlusal force–PL	30	39.58	17.47			
Pair 3	Relative occlusal force–AR	30	11.15	11.41	−28.599	−4.165	0.000
	Relative occlusal force–PR	30	39.75	19.49			
Pair 4	Relative occlusal force–PL	30	39.58	17.47	−0.176	−0.195c	0.845
	Relative occlusal force–PR	30	39.75	19.49			

Table 6: Paired *T* sample test correlation of the relative occlusal force in (boys and girls)

		N	Correlation	Sig.
Pair 1	Relative occlusal force–AL and Relative occlusal force–AR	30	0.784	0.000
Pair 2	Relative occlusal force–AL and Relative occlusal force–PL	30	−0.433	0.017
Pair 3	Relative occlusal force AR and Relative occlusal force–PR	30	−0.492	0.006
Pair 4	Relative occlusal force–PL and Relative occlusal force–PR	30	−0.327	0.077

Table 7: Paired sample statistics of EMG (girls and boys)

		N	Mean	Std. deviation	Mean difference	Z	p value
Pair 1	Electromyography–TAR	30	92.50	47.74	−15.320	−2.911	0.004
	Electromyography–TAL	30	107.82	51.86			
Pair 2	Electromyography–TAR	30	92.50	47.74	−72.108	−4.124	0.000
	Electromyography–MMR	30	164.61	74.98			
Pair 3	Electromyography–TAR	30	92.50	47.74	−98.100	−4.700	0.000
	Electromyography–MML	30	190.60	93.68			
Pair 4	Electromyography–TAL	30	107.82	51.86	−56.788	−4.165	0.000
	Electromyography–MMR	30	164.61	74.98			
Pair 5	Electromyography–TAL	30	107.82	51.86	−82.779	−4.783	0.000
	Electromyography–MML	30	190.60	93.68			
Pair 6	Electromyography–MMR	30	164.61	74.98	−25.992	−2.643	0.008
	Electromyography–MML	30	190.60	93.68			

Table 8: Paired sample statistics of EMG (girls and boys)

		N	Mean	Std. deviation	Mean difference	Z	p value
Pair 1	Electromyography–TAR	30	92.50	47.74	−15.320	−2.911	0.004
	Electromyography–TAL	30	107.82	51.86			
Pair 2	Electromyography–TAR	30	92.50	47.74	−72.108	−4.124	0.000
	Electromyography–MMR	30	164.61	74.98			
Pair 3	Electromyography–TAR	30	92.50	47.74	−98.100	−4.700	0.000
	Electromyography–MML	30	190.60	93.68			
Pair 4	Electromyography–TAL	30	107.82	51.86	−56.788	−4.165	0.000
	Electromyography–MMR	30	164.61	74.98			
Pair 5	Electromyography–TAL	30	107.82	51.86	−82.779	−4.783	0.000
	Electromyography–MML	30	190.60	93.68			
Pair 6	Electromyography–MMR	30	164.61	74.98	−25.992	−2.643	0.008
	Electromyography–MML	30	190.60	93.68			

individuals' bite force levels have been broadly used to understand the mastication mechanisms and the effects of their therapies.[11]

This study aimed to check if there was any correlation between the muscle activity and occlusal bite force distribution in asymptomatic young children of age group 9–12 years. A thorough search was done on studies related to the distribution of forces and the relationship between the occlusal contact and the EMG of the masseter and temporalis muscle. Therefore, studies involving the

mixed dentition age group are limited in the literature. During the mixed dentition age group, all the lower 1st permanent molars, incisors erupt and deciduous molars are still present or maybe on the verge of exfoliation.

Many studies show that there is a significant relationship between maximum occlusal bite force and the stage of dentition. This relation could be compared to the development of the stomatognathic system and masticatory muscle efficiency in different stages of dentition. The relation was significantly noticed by the transition stage of early mixed to late mixed dentition stage.[2] Sonnesen et al. who has done a similar study reported a significant relationship between the maximum occlusal bite force and the increasing stage of dental eruption in children aged 7–13 years.[12] Fontijin-Tekamp et al. suggested that masticatory performance improvised as the number of occlusal proximity increases.[1,13]

The bite forces may differ within the location of the oral cavity and force was maximum in the first molar region.[14]

The occlusal tooth contact is maximum in the posterior region due to the biomechanics of the jaw elevators muscles and the lever system of the mandible and is more in the molar region than on the incisors. At the age of 9 years, the age and gender are related to the force and they begin to increase at when the formation of the root of the first molar is complete. The average increase in the rate of bite force on the permanent molars in children.[1]

Our study was based on, asymptomatic young children where the maximum bite force was seen more posteriorly and on the left side region. It has also shown that the boys have maximum bite force compared to girls and the change in growth intensity between the male and female is the main reason for the difference in bite force in permanent dentition.[15] The correlation of bite force to gender is not evident till the age of 18 years because of the excretion of ketosteroids in postpubertal young males which is related to an increase of muscle mass. This increase in muscle mass occurs at a greater rate in males only beyond 16 years when compared to that of females.[1,16]

The present study also revealed that the voltage in healthy asymptomatic children which showed a significant result in masseter region in male than in the female.

Ferrario et al. in 2010 have done a similar study and has found out that the prevalence of the temporalis anterior in the female, while in the male there was a prevalence of masseter muscle which was also similar to our study in which the right masseter shows maximum muscle activity in boys compared to girls.[7,17]

Some other studies reported that the superficial masseter muscles EMG activity is significantly influenced by the T-scan sensor, whereas it does not affect the anterior temporalis in comparison to occlusion with the natural dentition. No studies were found on jaw muscle activity neither in normal occlusive children nor in children with unilateral crossbite within the early mixed dentition stage comparing differences between sexes. In normal young adults, some studies also found sexual differences with higher EMG activity in masseter or higher activities in masseter and anterior temporalis.[14,18] Shinogaya et al. in 1999 reported that the total bite force was 80% is distributed within the molar area. Therefore, within the present investigation, MVBF was measured within the first permanent molar region, and therefore the subjects were selected consistent with strict inclusion criteria.[19]

In this study, children of 9–12 years participated in the study. During this mixed dentition phase, the root resorption physiology of primary molars begins. Hence, the root of the molars may not have formed resulting in lower bite force.[1] In our study, all the first molars erupt which carries the maximum occlusal bite force. However, different factors might be attributed to the observed differences in the bite force magnitude, including various supporting structures of the teeth along with the child's tooth, changes in the maximum voluntary activity of the masticatory muscles within different regions of the dental arch, and the need to maintain joint stability during dynamic force production.

The findings procured from this study are important since they helped in determining absolute bite force and muscle activity in healthy young children aged 9–12 years. Thus, the data can therefore serve to provide a further reference for use in both pediatric dental and clinical practice and for further wider researches.

Conclusion

The T-scan Novus system has proved to be the most efficient method for the analysis and evaluation of occlusal bite force with the muscle activity interpretation using EMG. Though its cost is very high, it can be a reliable method for clinical evaluation and understanding of occlusal difficulties which are faced in day-to-day practice. It is definitely a valuable diagnostic tool that has high sensitivity and specificity. Therefore, this study concluded that there is a difference in the occlusal bite force and muscle activity in the mixed dentition which also concluded that the maximum force was on the permanent molars and the symmetry of EMGs activity in children was seen on the left masseter with higher bite values in male compared to female.

Acknowledgments

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