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ORIGINAL ARTICLE

A preliminary study to find a possible association between occlusal wear and maximum bite force in humans

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Abstract

Objective. The objective of the study was to investigate whether moderate-to-severe attrition is associated with maximum bite force in the first molar region. ***Methodology.*** Maximum bite force in the first molar region was measured for a total of 60 subjects having moderate-to-severe attrition of occlusal surface (experimental group) using a specially-designed piezo-electric sensor based bite force measuring device. An equal number of age, gender, height and weight matched controls (control group) were also subjected to bite force measurement for comparison. ***Results.*** The maximum bite force was found to be significantly lower ($p < 0.05$) in the experimental group [480.32 (153.40)] as compared to the controls [640.63 (148.90)]. While analyzing the possible etiology for occlusal wear mainly two reasons were elicited, i.e. history of parafunctional habits like use of known abrasive tooth powder (sub-group A) and Bruxism (sub-group B). However, there were many subjects in which no known definite etiological factors be attributed to occlusal wear (sub-group C). On analysing further with respect to the possibly correlated etiological factors with maximum bite force, no significant difference was found within the experimental sub-group. However, all three experimental sub-groups had significantly lower maximum bite force as compared to age, gender and BMI matched controls. ***Conclusion.*** A significantly lower maximum bite force was found to be associated with moderate-to-severe attrition as compared to subjects without attrition. However, no specific relation could be found between bite force and possible etiological factors like history of parafunctional habits, history of use of known abrasive tooth powder, etc.

Key Words: *abrasive toothpowder, Bruxism, piezoelectric transducer, tooth wear*

Introduction

Occlusal wear is a normal physiological process that occurs through life and leads to loss of vertical dimension of dentition [1,2]. However, if the rate of wear challenges the viability of teeth then it is considered to be pathological [1,3,4]. Moderate-to-severe occlusal wear (attrition) can lead to a reduction in tooth length and significant dimensional change in facial morphology [2,3]. A number of factors contribute to the loss of vertical dimension such as use of a hard tooth brush, parafunctional habits (bruxism, clenching), erosion, etc. [5,6]. Apart from this, some studies have proved that occlusal wear can increase by use of acidic substances because of a softening effect [7]. In the Indian sub-continent, the use of abrasive toothpowder is quite prevalent in rural areas. A few of the toothpowder preparations contain some chemical agents which can cause softening of the hard tissues of teeth and thereby predispose them for increased occlusal wear under normal masticatory forces.

Bite force evaluation has been accepted as a clinical indicator of masticatory efficiency [8,9]. The measurement of bite force has been considered as a reliable method of assessing the biomechanical properties of the human masticatory system *in vivo*, in both normal and abnormal conditions [10,11]. Studies have indicated that occlusal examination—the occlusal contact area and bite force measure of a patient—can provide valuable information for oral disease diagnosis, treatment and prognosis [12]. Research also underlines that the measure of maximum bite force is effected by numerous subjective factors such as: age, gender, strength of jaw closing muscles, state

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of dentition, pain threshold of subject, relevant facial structures, mental state during the experiment, malocclusion, signs and symptoms of TMJ disorder and objective factors like attitude of the investigator, location of the sensor in the dental arch for bite force recording and vertical separation of teeth and jaws [13–17]. It is postulated that the subjects with moderate to severe occlusal wear have reduced vertical height, thereby the bite force of these subjects should be lower than subjects without occlusal wear. In order to find out such a possibility, this study was planned to investigate the magnitude of mean maximum bite force in subjects with moderate-to-severe occlusal tooth wear and compare it with matched controls. This will give an indirect finding of whether there is an association between occlusal tooth wear and magnitude of bite force.

Materials and methodology

The present study was conducted after obtaining ethical clearance from the Institutional Ethics Committee. A bite force recording appliance was designed using a quartz piezzo electric sensor along with a charge meter and was calibrated for use. The details of the appliance are explained elsewhere in the text.

A total of 78 patients in the age group of 18–45 years with clinical findings of moderate-to-severe attrition but with a full complement of teeth (except third molars) were selected from a tertiary dental healthcare center, New Delhi, India for bite force measurement. The demographic details and relevant medical and dental history were recorded for the selected subjects after obtaining written informed consent. All subjects with a history of use of tobacco, pan masala or beetle nut chewing, compromised periodontal status and history of alteration of occlusion by restoration, crowns or cuspal grinding, splint or any other neuromuscular disorder and muscle in-coordination, muscle dystrophy or myasthenia gravis, communication disorder, loss of hearing, any surgery of the temporo mandibular joint (TMJ), history of trauma to TMJ and jaws, congenital abnormality, mental disorder and patients on immuno-suppressive drugs or muscle relaxants were excluded (total 18) from the study. While taking the medical, personal and dental history, mainly two major known possible etiological factors were revealed by the subjects, i.e. history of parafunctional habits like Bruxism and use of known abrasive tooth powder. However, there were many subjects in which no known definite etiological factors be attributed to occlusal wear. These subjects were accordingly sub-divided in three sub-groups namely (a) Abrasive tooth powder users, (b) Parafunctional habits and (c) no known etiology (n = 20 each).

Thorough oral examination was carried out in the all the subjects selected for the study. The TMJ, periodontal status and attrition of teeth, overjet, overbite and assessment of vertical dimension was carefully evaluated. A control group of 60 subjects with matching gender, age, height and weight to those of the experimental group were selected. The demographic details, medical and dental history and examination findings were recorded the same way as done for the experimental group.

Bite force measuring appliance

Although several devices have been reported for recording bite force in literature, Piezoelectric measuring devices are however widely trusted for their measuring accuracy, insensitivity to temperature changes, reproducibility and ease of use. Whenever a mechanical load is applied to a Piezoelectric crystal (e.g. quartz), there is stress generation in the crystal causing displacement of the electrons in a crystal lattice. This electron displacement causes generation of micro-current in the crystal proportional to the load applied, which can be measured in microvolts. The measurement of this voltage is converted into a force reading (in Newtons or N) using an amplifier and a charge meter. The piezoelectric devices have been used for all types of load applied, like compression, elongation, shear, etc. This technology has been used widely in modern day science including medical specialties like orthopedics, cardiology, rehabilitation, neurology, etc. The bite force is a compressive force, therefore a Quartz Miniature Force Sensor (9211A, M/s Kistler Inc., Switzerland) was used along with a Universal charge meter (5015A, M/s Kistler Inc.) with LC display.

The intra-oral part of the sensor was specially designed after consultation with mechanical engineers. This part of the appliance was made using two stainless steel (SS) plates (16 × 10 × 2.5) mm fixed at one end and mounted onto the base. A guide pin was used in the base SS plate for proper placement and in order to prevent flexure within the apparatus during biting. On one end of the plates the quartz sensor (height 6.0 mm) was placed in a trough (depth 1.0 mm) and the cable of the sensor passed through the gap between the plates and was attached to the charge meter with an LCD display (Figure 1). Therefore, the total thickness of the appliance transducer was 9 mm (6 + 1.5 + 1.5) mm. Although the sensor is pre-calibrated before supply, the assembled appliance was again subjected to compressive forces using standard weights as a load in the range of 10–500 N.

Method of bite force measurement

The subjects were seated in a dental chair in an upright position and were asked to maintain consistent posture. The method of bite force measurement was explained to the subjects through demonstration. The intra-oral part of the sensor covered in a

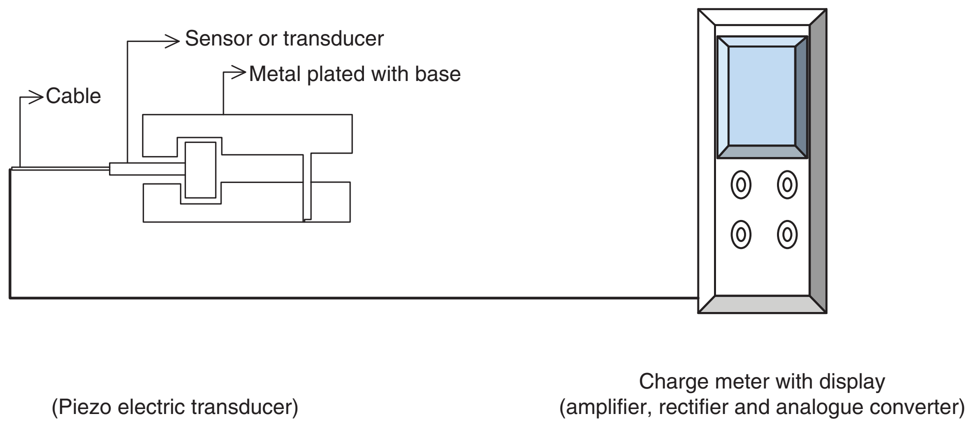

Figure 1. Schematic diagram of the bite force measuring appliance.

disposable medical grade plastic sheet was placed in the patient's mouth on the first molar area and an acrylic block was placed on the contralateral side to counter-balance the force. The measuring process required the subject to clench teeth with maximum force (Figure 2). The peak reading in the LC display of the charge meter was recorded in the proforma in Newtons (N or Kg m/s^2). The bite force was measured two more times with the same method after gaps of 3 min to avoid muscular fatigue. An average of the three values was then taken as the mean maximum bite force of that side of the jaw. After a gap of ~ 5–7 min the maximum bite force in the contra-lateral side was also measured with the same method. Finally, an average of both sides was taken as the maximum bite force of the individual.

Statistics

The data was fed into Microsoft Excel and then statistical analysis was done using SPSS version 11.5. For inter-group comparison, Student's *t*-test was used to compare between experimental and control groups. For intra-group comparison, analysis of variants ANOVA followed by post-hoc correction by Bonferoni's was used. A *p*-value of < 0.05 was considered as significant.

Figure 2. Clinical picture showing the position of the device at the time of measurement.

Results

In this cross-sectional observational study, the maximum bite force of the subjects with moderate-to-severe attrition was compared with age, gender, height and weight matched controls. Table I depicts the balance in the mean age, height and weight between the experimental and control groups. The statistical analysis shows that the groups are well balanced with respect to age (p = 0.410), height (p = 0.514) and weight (p = 0.524). Maximum bite force of all the subjects was recorded on both sides of the jaw and an average was used for comparing the two groups, although there was no significant difference in the bite force of the right [492.81 (149.24 N)] and left [498.17 (162.90 N)] sides (p = 0. 851) in the experimental and control groups [Lt. 660.82 (143.05) N and Rt. 663.30 (130.38) N, p = 0.921].

The maximum mean bite force of the experimental group [480.32 (153.41) N] was significantly less than that of the control group [640.63 (148.90) N] ($p < 0.01$) (Table II). There was little difference between the mean bite force values of the subjects with a history of parafunctional habits [518.17 (151.18)], history of use of known abrasive tooth powder [470.07 (158.32)] and subjects in which no known etiological factor could be ascertained [452.71 (150.79)]. However, when a comparison was made between the three sub-groups based on possible primary etiological factor elucidated by the history, the mean maximum bite force was not found to be statistically significant ($p > 0.01$). However, post-hoc analysis showed subjects in all three sub-groups have significantly lower bite force as compared to the control group ($p < 0.01$) (Table II).

Table I. Distribution of subjects in experimental and control groups.

Parameter	Group	*n*	Mean ± SD	SE	Inter-group comparison (*p*)
Age, years	Experimental	60	36.76 ± 7.96	1.02	0.681
	Control	60	35.51 ± 8.59	1.10	
Height, m	Experimental	60	164.26 ± 7.49	0.96	0.864
	Control	60	165.10 ± 6.40	0.82	
Weight, kg	Experimental	60	61.96 ± 9.85	1.27	0.717
	Control	60	62.98 ± 7.40	0.95	

Discussion

There are several types of bite force measurement devices reported in the literature, but, in the present study, a piezoelectric transducer-based instrument was used. The piezoelectric transducers have high modulus of elasticity. Even though piezoelectric sensors are an electro-mechanical system, they react on compression. Piezoelectric sensor are rugged, have an extremely high natural frequency and have an excellent linearity over a wide amplitude range. Further, insensitivity to electromagnetic fields and radiation, highly stable over temperature (1000°C), are inherent advantage of piezoelectric material. Piezoelectric transducers are accurate and reproducible, unlike other strain gauge-based oral force monitoring devices which have limited sensitivity, large size and also require frequent standardization due to permanent strains in their gauges.

To measure the bite force, a sensor was placed in the first molar region, as maximum bite force is exerted in the molar region. The literature suggests that the bite force in the incisor region is only one third to one quarter that of the molar region [9,17-23]. Bite force increases progressively in a non-linear but monotonic manner as the bite point moves posteriorly. This may partly be because of the lever effect of the mandible and partly because there is a larger area of periodontal ligament around posterior teeth [18]. This larger area of support is likely to reduce the inhibitory effect of nociceptive afferent voiley on force output.

Acrylic blocks of the same dimensions were placed on the contra-lateral side to balance the mandibular force [24-27], although Fields et al. [21] observed in their study that contra-lateral support is not necessary when recording vertical occlusal force in the first molar region. They also stated that the condition which might be expected to distribute the force more evenly did not reduce the vertical occlusal force but slightly increased it during chewing [21].

Results showed that subjects in both the groups had approximately equal bite force on the left and right side, which is in agreement with previous studies [11,28,29]. The results of the present study demonstrated that individuals with attrition of teeth with the use of locally manufactured tooth powder, bruxism or no definitive cause were associated with a reduced bite force when compared to matched controls. This reduction in bite force may be due to a decrease in vertical dimensions [30,31]. The difference in bite force when compared to the control was also significant in all sub-groups, but no significant difference in bite force was observed between different sub-groups.

Cosmo et al. [32] concluded that people with bruxism have no higher bite force as compared to

Table II. Bite force measurements in experimental and control group.

Group	*n*	Biter force in Newton ± SD	Inter-group comparison (*p*)
Experimental	60	480.32 ± 153.40	Exp vs Control
Control	60	640.63 ± 148.90	p = 0.00
Sub group A–Abrasive tooth powder	20	470.07 ± 158.32	A vs B p = 0.99
Sub Group B–Bruxism	20	518.17 ± 151.18	A vs C p = 0.99
Sub group C–Unknown cause	20	452.71 ± 150.79	B vs C p = 0.99
Control	60	640.63 ± 148.90	A vs Control p = 0.00 B vs Control p = 0.013 C vs Control p = 0.00

subjects without bruxism. Helkimo and Ingervall [33] also found that individuals with clenching and grinding habits were found to have higher bite force only in the incisor region, not in the molar region. This happens because the habits are normally performed in non-centric positions. The study conducted by Mantyvaara et al. [34] suggested that subjects with bruxism have over-strained masticatory muscles, leading to hypertrophy and higher bite force. Other studies [1,2] also suggested that the jaw closing muscles of subjects with bruxism might have benefited from a 'training effect', resulting in muscles that are stronger and more resistant to fatigue. Gibbs et al. [35] found higher bite force values on the posterior region for subjects with bruxism than for the control group. Johansson [36] carried out a cross-cultural study of bite force and concluded that increased tooth wear is related to magnitude of bite force. Other studies [37,38] explained unbalanced morphological occlusion lead to wearing of the tooth surface. On the basis of the results it appears that, instead of heavy bite force, uncontrolled movement appears to be the main causative factor for tooth wear.

The findings of the present study indicate that maximum bite force in subjects with moderate-to-severe attrition was found to be significantly lower than normal subjects, irrespective of etiology ascertained. Secondly, comparison of different sub-groups revealed that bite force alone does not appear to be a causative factor for tooth wear and further investigations are required in this direction.

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