Faculty of Dentistry

Elective Project Study

Course no. 703

Effects of Masticatory Forces on Anterior Tooth Movement

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Abstract

Objectives:

Modern diets in children require low bite forces, which may cause an increased incidence of malocclusion in adults. The aim of this experimental study was to determine the possible relationship between bite force and anterior tooth movement in young children. We hypothesized that the anterior component of bite force would be maximized at jaw openings greater than zero.

Methods:

The study included healthy subjects aged from 6-12 years. A thin-film sensor was placed between the lower first permanent and second deciduous molars. Simultaneously, a bite force gauge of varying thickness was placed between upper and lower first permanent molars on the same side of the mouth. During a bite, the force between upper and lower teeth and within the interdental space were recorded simultaneously. The combined data gave a three-dimensional representation of the force, allowing variation in the force pattern with gauge thickness to be assessed.

Results:

Of 18 subjects tested, usable data were obtained for 14. The ratio of the anterior-to-vertical components of bite force was measured for bite blocks of three differing heights. Statistical analysis demonstrated no effect of gape or

influence from the subject. Overall, the anterior component of bite force was ~5% of the vertical component.

Conclusion:

Contrary to previous literature, we found no significant influence of gape on the anterior component of bite force. Since this component is small, teeth will likely only move forward when considerable chewing forces are employed. An appreciation of this relationship could help understand jaw bone growth and tooth overcrowding.

Acknowledgments:

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Introduction and Background:

The normal development and function of the dentition is intrinsically linked to the jaws in which they are located. The teeth actually develop in a crowded manner inside the jaws. With eruption, subsequent bone growth separates the teeth so that they are arranged in the form of an arch. However, bones generally do not grow to their full potential unless appropriate mechanical stimuli are available [1]. Thus, it is possible that without sufficient force, jaw bones under-develop, leaving the dentition in a crowded state. Dentists refer to such misalignment as malocclusion, which describes a relationship between the teeth of the two dental arches that deviates from the ideal. Edward Angle, who is considered the father of modern orthodontics, was the first to classify malocclusion. He based his classifications on the relative position of the maxillary first molar [2]. However it is defined, malocclusion of the teeth is the norm in modern populations. For example, a study of adolescents in Kuwait found more than 70% of young adolescent Kuwaitis have moderate to severe malocclusion, with incisor misalignment being most common [3]. Only 13.7% were judged to have almost ideal occlusion, with the incidence in all cases being similar in boys and girls. The high levels of malocclusion in this Kuwaiti study are similar to those reported elsewhere, e.g. USA [4]. Other studies have shown slightly lower prevalence figures in American Caucasians, Africans, African-Americans, and European Caucasians [3]. While these discrepancies could reflect ethnic differences, the strict criteria for almost ideal occlusion in the Kuwait study may have contributed to a relative overrepresentation of subjects with malocclusion [3]. Whatever the exact figures, a high incidence of malocclusion in modern human populations is very recent, possibly only attaining significant levels about 200-300 years ago [5]. Prior to that period, malocclusion was a relatively minor issue in human populations (though it is seen in a 100,000 year-old human fossil [6]), as it is in other mammals including primates [7].

Cause of malocclusion

The prevalence of malocclusion is often thought to result from insufficient growth in the length of the dental arch. Crowding and misalignment of the teeth is presumed by Proffit to be related in part to the continuing reduction in jaw and tooth size in human evolutionary development [8, p. 159). However, as stated by Corruccini and Beecher [9], malocclusion is more often than not related to diet. Their experimental study on baboons raised on diets of varying consistency showed a clear link to malocclusion, the incidence of which was high in soft-diet baboons compared to hard-diet controls [9].

Despite this, the alternative of a genetic basis for occlusal variation has been discussed for roughly the past hundred years, with studies adapting varied methodologies. The classic work of Lundström on twins bolstered the impression of a stronger genetic than environmental component for occlusal variations [10-12]. The commonality of these studies has led the orthodontic specialty in general to conclude that genes are fundamental in causing malocclusion. Iwagaki, Stein et al. and Chung & Niswander all compared its prevalence among siblings or among offspring and their parents [13-15], finding that the chance of malocclusion in relatives of the maloccluded was significantly higher than in the general population. However, this proves little since family members also share greater environmental similarities than the general population [5, p.147-150]. In addition, the relatively high heritability of craniofacial dimensions and the relatively low heritability of dental arch variations have now been established, but exactly how this relates to the etiologic process of malocclusion that have both skeletal and dental components remains unknown [8 p. 159].

The question as to whether genetic factors or environmental factors may be the primary agent causing malocclusion has been widely discussed in the past. Genetic mechanisms are clearly predominant during embryonic craniofacial morphogenesis, but environment is also thought to influence dentofacial morphology postnatally, particularly during facial growth [5]. In general, it is accepted that these occlusal variations, excepting certain specific syndromes, result from a combination of genetic and environmental influences during development.

Yet, in certain human populations, the transition from predominately good to predominately bad occlusion occurred within one or two generations [5]. This evidence throws the weight of suspicion towards environmental, non-genetic etiologic factors. Environmental determinants such as non-nutritive sucking, mouth breathing, and abnormal muscle function, inadequate masticatory function, abnormal swallowing patterns, and premature deciduous tooth loss have a marked general effect on malocclusion. A study of effects of non-nutritive sucking habits on occlusal characteristics in the mixed dentition concluded that 55% of such children had malocclusion, and the incidence of anterior open bite and posterior crossbite was associated with sucking habits lasting 36 months or more [16].

The importance of bite forces and diet

Since the 1890s, oral biological researchers have been interested in the idea that strenuous mastication of unprocessed food will stimulate proper orofacial growth and occlusal relationships. Conversely, lack of such function due to consumption of refined food is one hypothesis among many for the etiology of malocclusion in industrialized humans. Malocclusion thus is a malady of "civilized" humans [17]. This observation gives rise to a theory widely favored among anthropologists: that malocclusion arises from the lack of chewing stress in the modern processed diet and the ensuing lack of stimulation and direction provided to the growing jaws and erupting teeth [18,19]. After some discussion, Moyers concedes "the evidence seems to indicate that our highly refined, soft, pappy modern diet plays a role in the etiology of some malocclusion" [20]. Moreover, Hooton opined that, although an evolutionary trend in reduction in facial and dental growth has long existed, the process has suddenly been accelerated under urban, cereal diet conditions [21].

Dickson offered a slight variant in reasoning, arguing since that not everyone is affected, one can speculate that some individuals possess a genetic background less conducive to the proper development of their jaws in the absence of this factor [22].

Moderate differences in the hardness of diet are related to significant differences in maxillary width and other measures of facial size. Muscular stimulation mediated through occlusal function seems to play a significant role in the coordinated development of facial structures [5]. Consequently, a major factor implicated in the trend towards malocclusion may be the very low bite forces necessary for consuming a modern diet [5]. This favors the hypothesis that dietary consistency and toughness promote alveolar modeling and proper permanent tooth eruption. On the other hand, the interproximal attrition brought about by high bite forces may increase arch space in many peoples living on less processed diets.

The ultimate cause of the dramatic change in food texture in modern populations may be cooking, which is defined as the application of heat in order to improve the nutritional quality of food [23,24]. It has a universal revolutionizing effect on nutrition and ecology on the species that invented it. When and where cooking has started is unknown. However, signals in the fossil record such as smaller teeth signify reduced digestive effort, suggesting that cooking could have become a common practice at ca. 1.9 million years ago. "Cooking may be cultural, but current evidence suggests that its effects have fed back into our biology, and have thereby created constraints that importantly shape and define our evolutionary biology" [23]. Prior to the development of cooking, humans fed on hard, raw unprocessed food that required larger jaw openings and stronger bite forces. Meanwhile, with dietary adaptation, people eating highly cooked foods use less bite forces and less jaw opening, which might explain the increased prevalence of malocclusion.

Mechanism by which bite force affects bone growth

As suggested above, a major oral physiologic aspect of human occlusal variation, one which is deeply affected by cooking, is the force of biting. This force, which is applied between the maxillary and mandibular teeth resulting from contraction of the masticatory elevator muscles, is known as the bite force (Fig. 1).

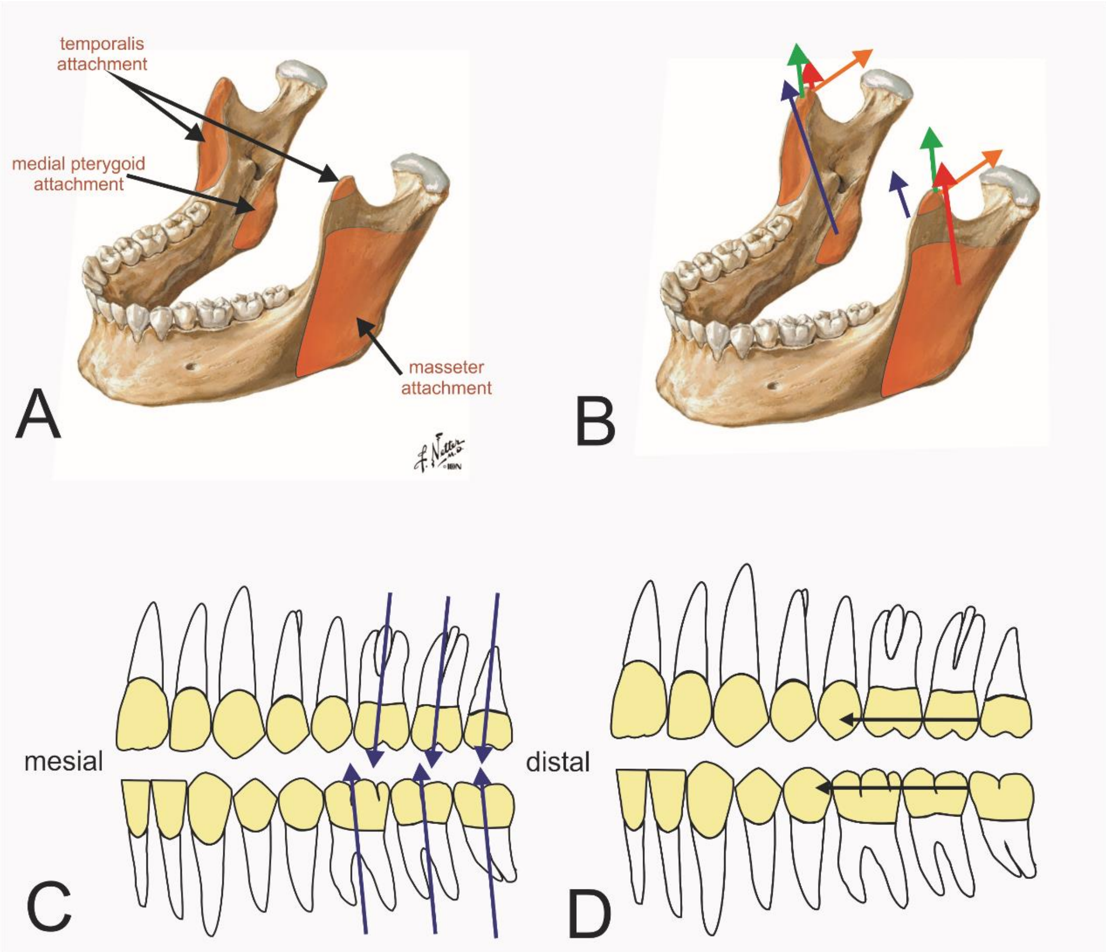

Fig. 1. A, the attachments of the most powerful jaw elevator muscles are shown on a mandible (from Netter). **B**, the directions of these, expressed maximally in a static bite, would tend to produce an anterior component to the bite force (medial pterygoid in **black**, anterior temporalis in **green**, posterior temporalis in **orange** and masseter in **red**). **C**, the teeth (permanent dentition is illustrated) tend to develop an anterior tilt (**blue** arrow). **D**, this tilt, coupled to muscular action, would tend to drive teeth forwards in a bite (**black** arrow). The question posed here is whether this component is greatest when the teeth are occluding, or instead when someone is biting a piece of food of variable dimensions (mimicked in this study by bite blocks of different sizes).

Several studies have been conducted to demonstrate bite force and its relation to tooth movements using different methodologies. Due to the diversity of the methods and materials used, various conclusions have been reached regarding the aspects of such forces. Despite the discrepancies in conclusions, all studies acknowledge the existence of tooth movement. Proffit implied that a stable occlusion would only result when a balance in terms of the magnitude, duration, and direction of forces is achieved between four primary factors, one of which is the influence of forces on the occlusion [8].

The bite force may not be directed purely vertical, but possess components in both buccolingual and mesiodistal directions. The mesiodistal aspect is split into directional components (anterior and posterior) that act through contact surfaces between adjacent teeth in the same arch. Such components of bite force have been identified by observing an increased interproximal contact tightness that is noted mesially and distally when a given tooth is loaded. Conroy investigated the posterior component of occlusal force, in which his results stated the presence of a posterior component [25]. However, the magnitude of this was small compared to that of the anterior component of occlusal force generated for a given loaded tooth, which is the aspect of tooth movement for which there is most evidence [25].

The anterior component of the bite force has been measured most often by inserting thin metal strips into interdental spaces [26,27]. The force needed to remove these strips during biting can be converted into an estimate of the force between teeth. The method is indirect in that the force between teeth is inferred from the force needed to remove the strip. By investigating the forces between different spaces, it can be established whether teeth are being pushed anteriorly or posteriorly. In humans, an anterior component is the most common [25]. It is known that teeth drift mesially in humans [28]. It is logical to think that this drift is being driven by the anterior component of bite force [26]. However, it may do more than this. In young children, it may also contribute to the anterior bone growth necessary to space the teeth out. For example, misalignment of the mandibular anterior teeth has been found to be related to the magnitude of the anterior component of occlusal force and to the tightness of interproximal contacts in the mandibular posterior segments [25]. Low bite forces associated with modern cooked diets would obviously be expected to reduce the anterior force.

Rationale for this Project

The purpose of this experimental study is to pioneer new methods of quantifying the anterior component of bite force and whether it has an implication on malocclusion. Evaluation of interproximal contact forces mesial to the loaded teeth will provide an opportunity to establish and quantify an anterior component of bite force.

Material and Methods:

The subjects were drawn from a sample of children, aged 6-12 years, attending dental clinics in Kuwait. A sample of 18 children were enlisted in the study with the full consent of their parents (the form used is appended to this report), after exclusion of subjects for the following reasons: gross caries, open contacts, missing deciduous molars, partially-erupted permanent molars or due to their anxiety about the procedure.

The measurement apparatus consisted of two separate elements: interdental sensors and bite force gauges. For force sensors placed in interdental spaces, we used Uneo™ sensors (UCCTW, Taipei, Taiwan). These are ultra-thin flexible pressure sensors in the form of circular discs (Fig. 2A). In this experiment, we used two variants: GS05-10N (5-mm circular discs of 0.25mm thickness) and STY04 (4mm in diameter and 0.2mm thick). The latter discs were specially made for this project. These thin-film force transducers are based on patented resistive sensing technology that picks up the change in resistance produced when the two sides of the film are pressed together. In the resting state, the resistance across the sensor is very high, but this drops quickly when it is pressed on. The sensors were wired to an amplifier circuit in the form of a Wheatstone bridge. This was built in the HSC Biomedical Engineering Unit by Mr Vladimir Zika. This converted the output of the sensors to a voltage. The signal from the amplifiers was then passed to a 16-bit analog-to-digital converter (NI 6210, National Instruments, Austin TX, USA) powered by the USB port of a laptop computer.

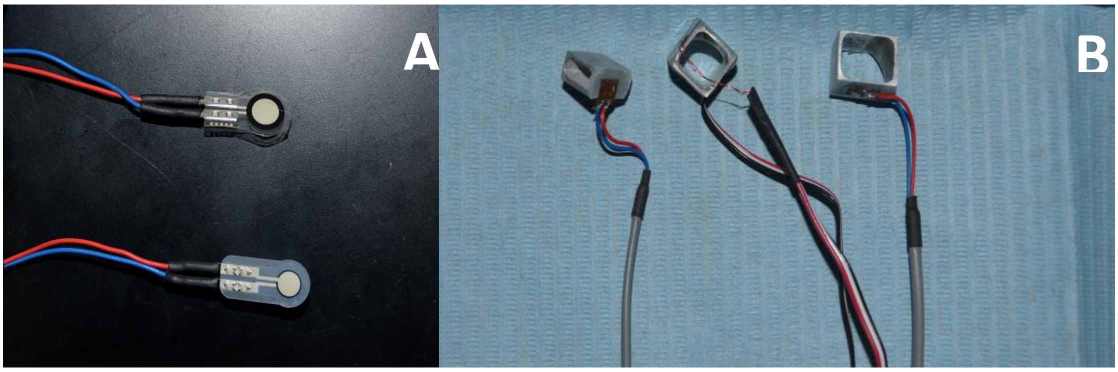

Fig.2 A, the interdental sensors used: GS05-10N (5-mm circular discs of 0.25mm thickness) and STY04 (4mm in diameter and 0.2mm thick). **B**, the three different sizes of bite gauges used in most experiments (5 mm, 10 mm, and 15 mm).

The varying voltage output of these sensors was individually calibrated to a force by placing them in a small portable testing machine equipped with a 50 N load cell. The calibration was designed to resemble the contours of adjacent teeth at their contact point. The contacting surfaces on either side of the machine were the sides of 6.35-mm stainless steel spheres, which were placed in contact with the centre of the sensor (Fig. 3).

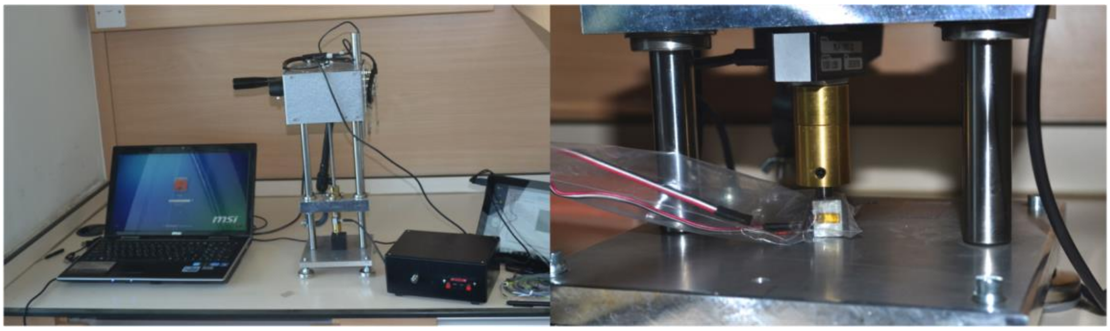

Fig. 3 Calibration of the bite blocks and interdental sensors

The other elements of the apparatus were the bite force gauges (Fig. 2B). There were four of these, each machined into the form of rectangular hollow aluminum boxes, of about 1 mm wall thickness, from stock aluminum rods by Mr Rudolf Kusy (HSC Biomedical Engineering Unit). The gauges were either 5 mm, 10 mm, 15 mm or 20 mm in height. Each box was ground with increasingly fine abrasive papers to smoothen the outer surfaces on which the strain gauges were to be bonded (Fig. 4A). This eliminated surface interferences that could interfere with strain gauge function. The design of the bite force gauges was modified from that of Osborn and Mao [29].

Fig. 4 A, each bite block was ground with increasingly fine abrasive papers to smoothen the surfaces. **B**, bonding of the strain gauges to the sides of the frame. **C**, insulating the block with a layer of clear epoxy resin.

We bonded two small strain gauges (Micro-Measurements, Vishay, Raleigh NC, USA) to the sides of the frames (Fig. 4B), remote to (out of contact with) the biting surfaces and positioned so to detect both vertical and bucco-lingual components of the bite force (Fig. 5 below). After bonding, the gauges were insulated by a thin layer of slow-setting cold epoxy resin (Fig. 2, C). The strain gauges were connected to a 24-bit analog-to-digital converter (NI 9235, National Instruments, Austin TX, USA), which was powered by another USB port of the laptop computer and calibrated using a mechanical tester with a 500 N load cell (Fig. 3). In this case, the sensors lay on a flat surface, contacted by a 6.35-mm diameter spherical probe. The exact contact details should not matter in this case because the form of loading will not affect the strain distant to the point of contact. Thin wires ran from each bite force gauge and interdental sensor back to the analog-to-digital converters and the data were recorded on the computer screen in real-time.

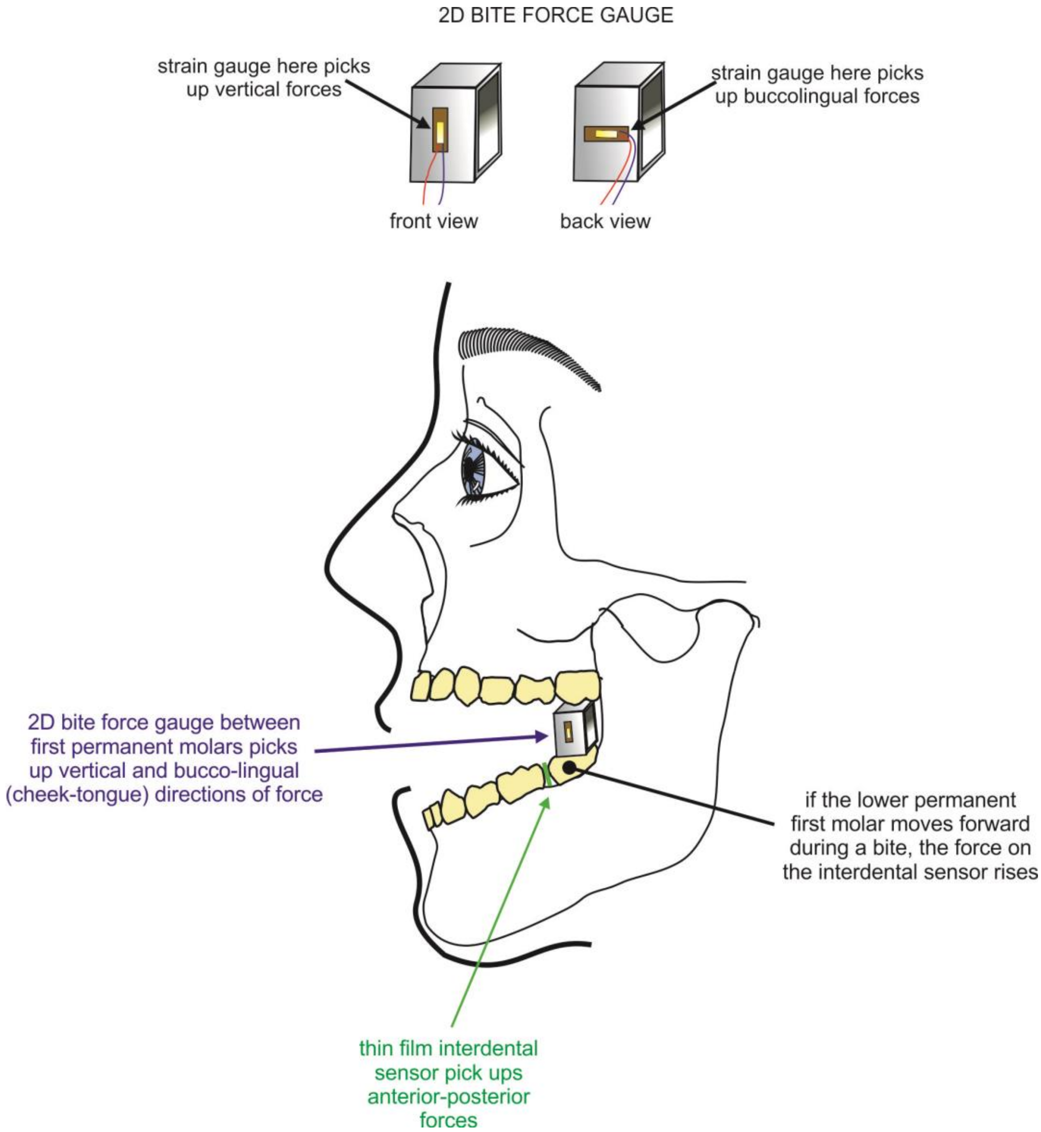

Fig. 5 Above, two strain gauges (shown as **blue** arrows) were placed on an aluminum box and calibrated to produce a two-dimensional bite force gauge. Four such bite blocks were made with different heights, but only three were used in most of the experiments. **Below**, a gauge has been placed between the first permanent molars of a subject. An interdental sensor (shown as a vertical **green** line) was then placed anterior to the lower first permanent molar, space being made available for it by the use of a separator prior to experiment. Any anterior movement of the lower permanent first molar causes the pressure on the interdental sensor to rise.

The information revealed from the interdental sensor comes from its placement mesial to the target biting tooth (Fig. 5). If the force rises, then it is directed anteriorly; if it falls, then it is directed posteriorly. The combination of data from these bite gauges, together with the antero-posterior component detected by the interdental sensor, gives a full three-dimensional representation of the bite force.

Experimental Method

The two experimenters made all measurements on the subjects. Prior to experiment on each subject, subjects presented to Kuwait University Dental Clinic where the separator was placed between the lower first permanent molar and the lower second deciduous molar to create a sufficient interdental space for the sensor to be placed (Fig. 6). The second part of the experiment, which did not involve clinical procedures, was conducted in the lab. After 3-4 hours, the subject returned and was escorted to the laboratory setup (Fig. 7), the separator was removed and the contact tightness evaluated. The different bite blocks were each freshly covered in a plastic wrap prior to placement in the mouth and the wires shielded from direct contact with the oral tissue. In order to preserve effective infection control for each subject, individual interdental sensors were wiped using alcohol swabs and wrapped using disinfected parafilm up to the wires that were in contact with the oral tissues. All subjects sat upright to eliminate any source of error due to postural changes.

Fig. 6 Illustration of the **light blue** orthodontic separator placed between the second deciduous and the first permanent molar.

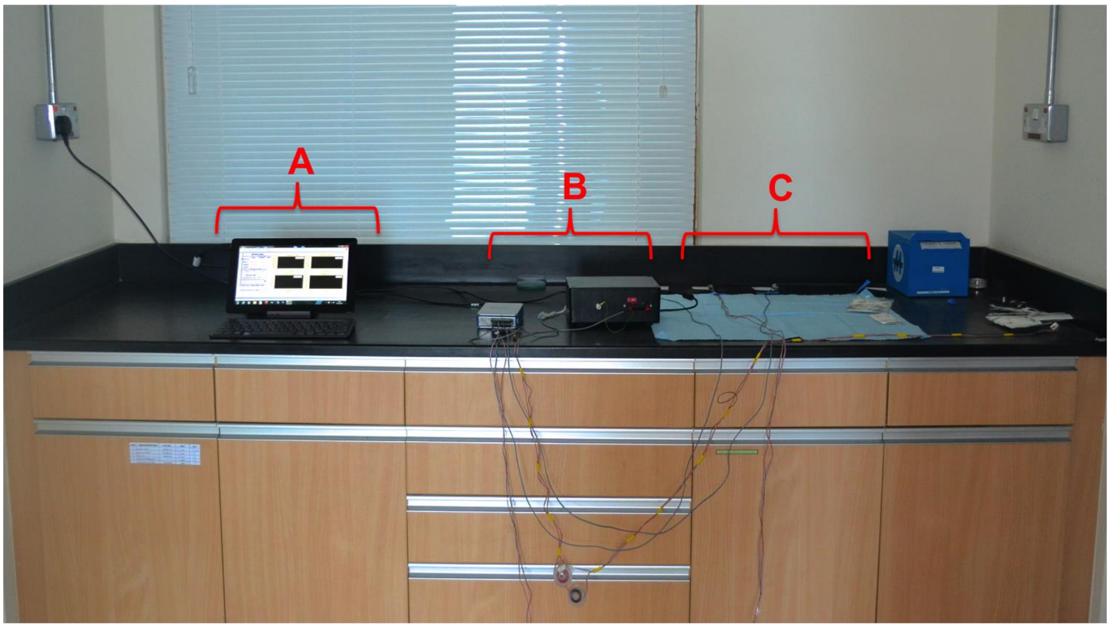

Fig. 7 The experimental set-up showing **A**, computer interface, **B**, digital analog converters and **C**, the bite blocks and interdental sensors ready for use.

One observer explained the procedure of biting to the participant and then placed the sensor interdentally first, followed by the bite block. The second observer controlled the computer and read the recordings. Once the computer was started, the subject was instructed to bite with gradually increasing intensity on the bite force gauge and then to release the bite on command. Each subject was asked to do so at least three times. The bite block was then removed, the next one of differing height substituted and the procedure with the subject repeated.

Signals from the bite force gauge in use and the interdental sensor passed direct to the computer where they were shown on screen in real-time. Stored records were later retrieved and the calibration factors introduced to convert both signals to forces. The strain gauge data could be converted to forces very readily. However, the bucco-lingually positioned gauges (Fig. 5, above) rarely gave signals above the noisy error range. They were disregarded and not analyzed. Before the interdental sensor signal could be converted to a force, another factor additional to the machine calibration had to be estimated. These sensors are pressure sensors, which means that the difference between the area of the sensor loaded by the two stainless steel balls and the area between two teeth had to be standardized. It was found impossible to model the interdental contact in every subject. Thus, we decided to model it using Nissin dental models using a left second deciduous molar and a left permanent lower first molar. These were pressed together while separated by a thin sheet of dental wax. The wax perforated to produce a circular hole. The diameter of the hole was measured. Compared to the contact between the two steel balls, the contact area between the teeth was about 40 times larger. This is approximate, but the best that could be estimated. Thus, the force estimated for the interdental sensor from the machine was divided by 40 and then compared to the vertical force. Having done this, the interdental force could then be plotted against the vertical force. The slope from linear regions of the graphs gave the proportion of the force that drove teeth forwards, i.e. the anterior component of bite force could be given as a percentage of the vertical force.

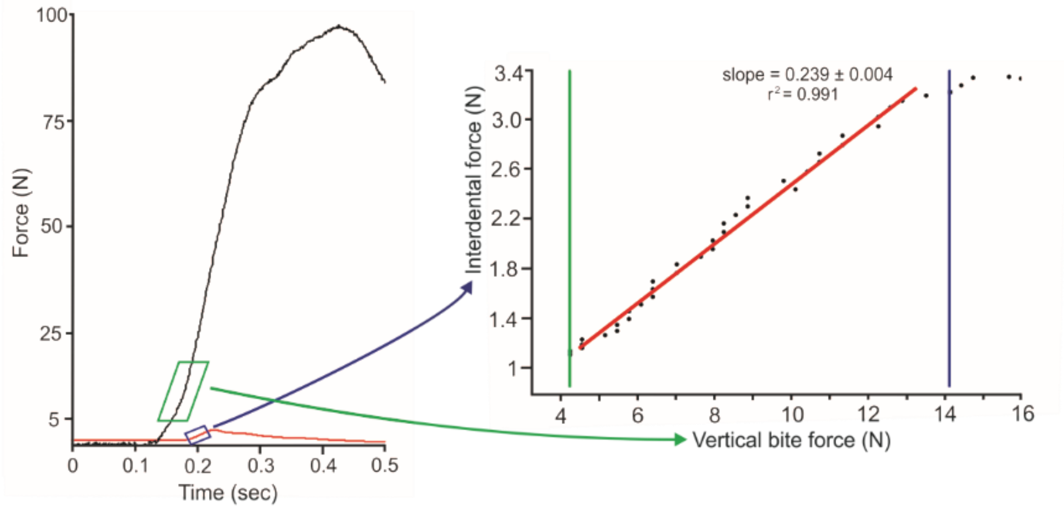

Fig. 8 The method of obtaining the proportion of the bite force that is directed anteriorly. **Left,** a fraction of the force records (vertical bite force in **black**; the interdental sensor in **red**) are plotted against time. The rise in bite force precedes an increase in the interdental force by about 0.03 second in this recording. The boxes surround the sections of the record sent to the graph at **right**, where the ratio of the anterior to vertical bite force was obtained by least-squares regression (for the data between the **green** and **blue** cursors, which were user-settable). The slope and its standard error were shown on-screen, along with r^2, which indicates how much of the variation is accounted for the least-squares fit.

The final dataset from the study consisted of estimates of the proportion of vertical force that had an anterior component. These estimates came from three sensors – 5 mm, 10 mm and 15 mm in height. Only one slope was considered for each subject. An average was taken when more than one estimate was available and these estimates were close in value. If they were far apart, then the estimate with the smallest error was taken. An analysis of variance (ANOVA) was then run on SPSS ver. 17 to establish whether the proportion of the force directed forwards varied between the different blocks. Data were transformed to their natural logarithms prior to analysis to normalize the data.

Results:

An example of a data trace for a subject in the study is shown in Fig. 8. The rise of force between teeth recorded by the interdental sensor could be simultaneous to the rise in the bite force, but often there was a short lag of up to 0.1 seconds. Although we also measured the bucco-lingual direction of the force, this was rarely large and above error level and thus was not analyzed. The ratios of the anterior to the vertical component of the bite force are presented in Fig. 9 for all subjects.

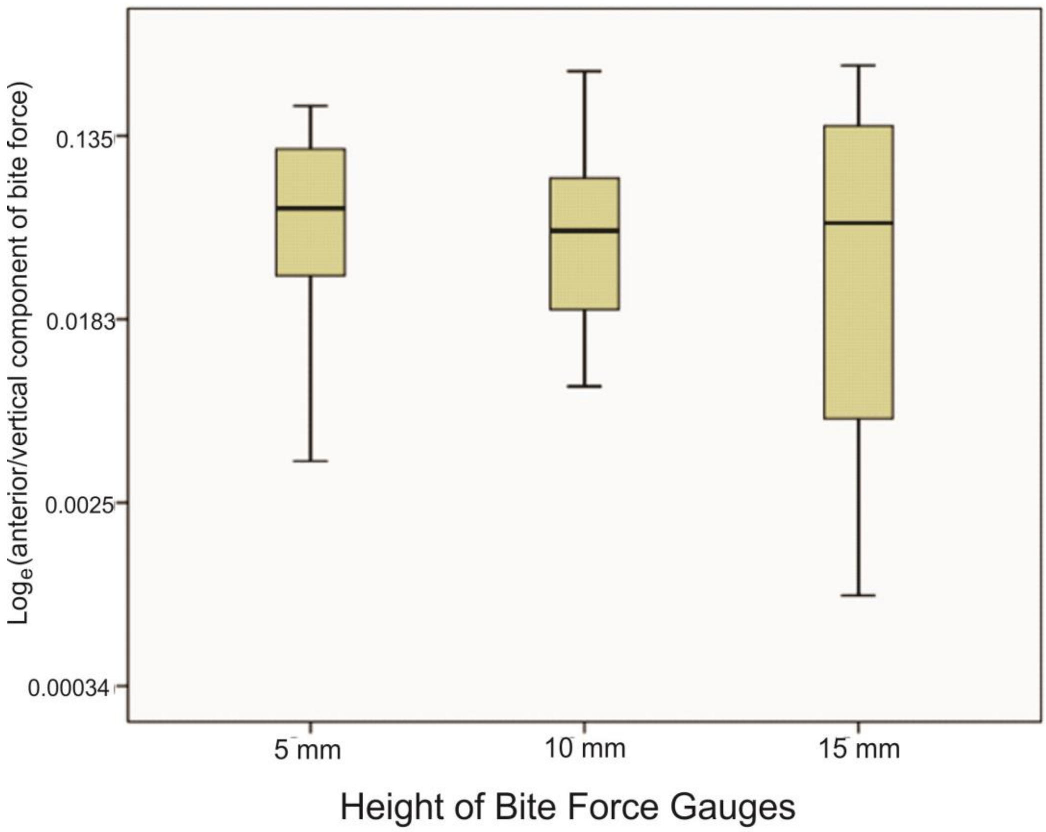

Fig. 9 Means and ranges for the ratio of the anterior to the vertical component of the bite force for all data in the experiment (n = 14 subjects). The data have been logarithmically transformed to approximate a normal distribution. The box represents the second and third quartiles (i.e. the central 50%) of the data.

The means were 0.053 (95% confidence interval for mean: 0.053-0.099) for the smallest (5 mm height) bite gauges, 0.046 (bounds: 0.023-0.091) for those of 10 mm height and 0.0349 (bounds: 0.013-0.0.096) for 15 mm gauges. The highest overall ratio was for gauges of 5 mm in height, but there was no significant effect seen of the height of the bite gauge (F_{37} = 0.346, p = 0.710). Overall, an average of about 5% of the bite force was directed anteriorly.

Discussion:

This is the first study to our knowledge that has measured the force between adjacent teeth in the same arch simultaneously to the vertical component of the bite force. Unlike previous studies, we measured bite forces using a novel 3-dimensional method that included real-time monitoring of active interdental sensors in an *in vivo* experimental situation. This study is also apparently the first to investigate the anterior component of bite forces in children and the potential effect that it exerts on bone growth and development. By age 6, permanent teeth are beginning to erupt and jaw is continuing to grow. Thus, the age group is of particular interest for our experiment. We observed no significant effect of the gape (separation of upper and lower teeth during a bite) on the anterior component of force, suggests that this has little or no effect in children of this age group and dental stage. On the other hand, the large deviation in our data set could indicate that with a larger sample size, a significant pattern could be revealed.

Osborn concluded that during the clenching of teeth by adults, all teeth are pushed mesially [26]. Southard et al. found that there is a proportional increase in the anterior component of the bite force with increasing gape [27,30]. In our study on children, we found no significant difference between the anterior force component with the different bite block sizes used. The results we achieved may be due to differing methodology from Osborn and Southard et al., i.e. real-time data capture, or to the different age groups studied, or to the fact that we did not study maximal forces. Another explanation might be that Osborn [26] measured the interdental forces between the teeth in the same arch during the clenching of the jaws, while we measured something more similar to a normal masticatory force.

However, although our results showed no significant difference between different bite blocks, we did demonstrate that only a small fraction of the bite force, approximately 5%, is transmitted in an anterior direction. This has implications for diet. For example, assuming that a child is chewing on food with an average masticatory force of 150 N (which is itself liable to be an overestimate for modern diets), then the anterior component of bite force pushing the teeth forward, according to our data, would be 5% of that, which is just 7.5 N. This is a low force, acting over a very short period, that may not be sufficient to stimulate bone growth in the jaw. The forces that move teeth have been discussed extensively in the orthodontic literature [31]. Acting over a long time period, even forces of 0.02 N can move teeth [32], but there appears to be no information over forces that act only over a fraction of a second. This result is even more important when we consider that a modern human diet, consisting mainly of soft compliant food, does not require large masticatory forces to process. The relationship described here may therefore have great relevance to the increasing prevalence of dental misalignment and suggest exactly why offering a diet to children that requires higher chewing forces could be critical to alleviating the condition. There is little accurate information on this topic because of the difficulty of measuring chewing forces.

There is one extra, and totally unexpected, bonus from this study: if the anterior component of bite force were to be a constant proportion of the vertical force in individual children, then an interdental sensor might serve as an indication of the chewing force without interference with the chewing process. This is a completely novel suggestion, but one which would require further miniaturization of the interdental sensor to achieve. The value of doing so is indicated by some data from Corruccini [5]. In an investigation of the possible relationship between bite force and occlusal variation in the youths of Northern India in 1985, Corruccini found that there is a significantly higher bite force in rural versus urban youths. He suggested that the habitually 'heavier' mastication of rural youths might be helpful for a better occlusal scheme [5]. It must be emphasized, however, that maximum bite forces and their relationships to gape [33], which are what most studies measure, may not have any simple relationship with the forces used in chewing food.

Limitations of the Study

As with any experimental study, several limitations were faced. The criteria for selecting the subjects made them quite difficult to find due to the dynamic nature of the primary dentition, mainly influenced by the increasing caries risk that leads to grossly carious surfaces and eventual unnatural exfoliation.

Another obstacle was the variation in the eruption sequence of children and eruption level. Several children aged 6-7 years were examined, but not all had a fully erupted first permanent molar. Even if it was present, the deciduous molars might have already exfoliated or be unstable due to highly resorbed roots. The contact point between the second deciduous and first permanent molar was also an issue, due to the variation in tightness of contact between an individual and another. A separator was placed to overcome this obstacle. However, the time needed to separate the teeth by this method also varied. For some, it was two hours, while others needed four hours. Numerous subjects were potentially eligible for the experiment. However, in several, when the separator was removed after four hours, the contact needed was still not achieved. These subjects all had to be excluded.

In addition, a few subjects refused to come back after placing the separator, or were anxious. So these subjects were excluded (or excluded themselves). These limitations created some obstacles to our sample size. The drawback of the separator that was initially used was overcome with a stronger separator, which required less time to separate the teeth. However, after bringing in subjects for the second time after the removal of the separator, it was found difficult in quite a number of them to place the interdental sensor accurately, which also led to their exclusion thus decreasing the sample. Also, after getting the apparatus in place, and asking the subject to bite down, some wires occasionally fractured, sensors saturated, bite blocks distorted and strain gauges dislodged. The 'homemade' nature of the apparatus, built or assembled (in the tradition of physiological experiment) especially for this project, sometimes led to a need to repeat the recordings, which not all subjects agreed to. Although subjects were comfortable with the 5, 10 and 15 mm bite blocks, the positioning of the 20 mm bite block was difficult to achieve because the gape was too large for subjects to tolerate.

Conclusion:

This novel study showed no significant difference in the anterior component of bite force in relation to different bite block sizes. We showed that this component approximates only to around 5% of the vertical masticatory force. These results are different compared to other studies. However, they contributed more data to an extremely limited literature. This study therefore could be considered as an effective pilot for further investigations that incorporate a full cohort study that could include dietary

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Evidence of Ethical Approval

Eino Honkala

In response to the message from Fatma Al-Kazimi, 3/16/2013

Actions

To: Fatma Al-Kazimi

Cc: Peter Lucas

Sunday, March 17, 2013 4:35 PM

Dear Fatma,

Your project was approved by the HSC Ethical Committee for the Students to-day.

With kind regards,

Eino

JOINT COMMITTEE FOR THE PROTECTION OF HUMAN SUBJECTS IN RESEARCH OF THE HEALTH SCIENCES CENTRE (HSC) & KUWAIT INSTITUTE FOR MEDICAL SPECIALIZATION (KIMS)

Informed Consent (Parent)

Faculty: ……Dentistry……………… **Hospital:** ………………………
Department: ……………………… **Department:** …………………………
Title of the Project:
…The Effect of Masticatory Forces on Anterior Tooth Movement …………..

Purpose of the Study:

1- To determine the possible relationship between bite force and front teeth movement.
2- To measure the direction and degree of bite forces related to jaw growth using thin force sensors.

Procedures:

We will start by taking the child's relative medical and dental history. The child is asked to open his/her mouth. A thin sensors will be placed between the permanent first molar and the second deciduous molar; this will be established by inserting an orthodontic separator (a small blue rubber band) a few hours (3-5 hours) prior to the trial to temporarily relief the contact, thus allowing the insertion of the sensor under the supervision of a specialist doctor. The child is then guided to bite down on a block slowly and recordings will be made on a computer. This procedure is repeated four times, each time with a different thickness of the block (approximately 5mm, 10mm, 15mm, and 20mm). Each bite block and sensor will be wrapped in plastic to meet universally-applied precautions for infection prevention.

Agree **Patients Name:** **Signature:**

Don't Agree **Patients Name:** **Signature:**

Investigator's Name: **Signature**
Investigator's Tel.:
Date:

JOINT COMMITTEE FOR THE PROTECTION OF HUMAN SUBJECTS IN RESEARCH OF THE HEALTH SCIENCES CENTRE (HSC) & KUWAIT INSTITUTE FOR MEDICAL SPECIALIZATION (KIMS)

Assent Form
(Children 7 – 17 Years of Age)

Study Title
The Effect of Masticatory Forces on Anterior Tooth Movement.

Meeting Date with Patient ……………………………………………

1. What will happen to me in this study?
   You will present to the dental setting and basically, you will be asked to bite on 4 different bite blocks, and a sensor will record the bite force.

2. Can any bad happen to me?
   There is no harm in the study, except for slight discomfort if you bite hard.

3. Can anything good happen to me?
   If the hypothesis is approved, the benefit is anterior bone movement which will decrease the chance of malocclusion.

4. Do I have other choices?
   It's your will to participate or not.

5. Will anyone know I am in the study?
   No names will be taken, and all information are stored safely in our records which are only accessed by us. Patient confidentiality is a guarantee.

6. What happens if I get hurt?
   Hopefully there is no harm, except for mild discomfort if you bite hard.

7. Who can I talk to about the study?
   From our side, all information is confidential, however you can talk to anyone you want and mention that you have participated and mention the details.

8. What if I do not want to do this?
   It's your right to choose if you agree on participating or no.

SIGNATURE

If you agree to be in this study, please sign here:

Signature of Child

Investigator's Name: **Signature**
Investigator's Tel.:
Date: