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Bite force part II – Devices

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Abstract
For the masticatory system to be functioning, the maximum voluntary biting force must be evaluated. It is impossible to find a special solution that combines desired qualities like dependability, accuracy, precision, usability, and comfort. This is because a number of factors affect the estimation of this force. This page lists the various tools available for measuring bite force.

1. Introduction

The individual bite force is generated by teeth during dental occlusion. The muscles used for mastication can be determined in large part by the bite force.The evaluation of prosthetic devices as well as the evaluation of therapeutic methods are two key purposes for which this force is utilised in dentistry. This force is influenced by a number of variables, including age, gender, the spatial offset of the teeth and mandible, the stress on the periodontal tissue, etc.The mechanical characteristics of the recording system, the location of the device, have an impact on the bite force measurement in addition to these biological aspects.

Numerous research have been conducted on the biting force using a variety of instruments. The measurement of bite force is produced using electrical or electronic sensors based on resistance, capacitance, inductance, strain, piezoelectric, or thermoelectric property, each of which has its own inherent shortcomings. [1]

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2. Currently Used Transducers for Measurement Of Bite Forces:

Strain Gauge Transducer

It is a pressure transducer that uses elastic sensitive components and strain gauges to translate the measured pressure into a proportionate change in resistance value. It is composed of elastic components, compensating resistors, and resistance strain gauges, which are typically used to detect higher pressures.

The main element of the strain gauge transducer is a sensing component that can convert the change in strain on the mechanical component into a change in resistance. The strain gauge's resistance variation changes in direct proportion to deformation.[2] Strain gauge transducers can be used in a variety of situations and have a wide measuring range, high sensitivity, and accuracy. They are also lightweight and tiny.

It has been demonstrated that the strain gauge transducer accurately measures force of bite, however it is still challenging to capture the actual maximum force of bite. The individuals felt uneasy or anxious upon biting the sensor, which was mostly owing to its rough surface.

Some researchers have attempted to cover the metal bite fork surface with protective covers.[3] The placement of the bite fork may have an impact on the findings of the bite force measurement, which is another significant drawback of the strain gauge transducer. According to certain researchers,the bite force registered by the sensor further distal is greater than mesial due to mechanical leverage produced by the thick metal plate of the bite fork utilised in the strain gauge transducer.[4]

Piezoresistive Transducer

They are made using integrated circuit technology and the piezoresistive action of a single crystal silicon material. After applying the force, the resistivity of the monocrystalline silicon material changes, and a measurement circuit can be used to extract an electrical signal output proportionate to the force change.[5]It offers a wide operating temperature range, strong stability, high measurement accuracy, quick dynamic response and ease of mass production, which has led to its widespread application. It is a transducer that shows promise and is frequently utilised in the medical industry. Currently, a variety of tiny sensors are employed to gauge the pressure in the heart, urethra, cerebral system, and eyes.[6]

Pressure Transducer

A piece of equipment called a pressure transducer transforms fluid or gas pressure into electrical impulses. It has an air or liquid-filled chamber. Under pressure, the chamber's internal pressure rises and is conveyed for measurement to the pressure gauge. Pneumatic and hydraulic pressure transducers can be distinguished from one another based on the contents of the chamber.[7]

Piezoelectric Transducer

A piezoelectric transducer transforms the measured pressure into an electric signal. Piezoelectric substance makes up the sensitive element.Piezoelectric transducers are lightweight and of a modest size. They are stable, reliable, and have excellent stability because they don't have any moving parts. After being pressed, the piezoelectric material produces electric charges on its surface, which are amplified and transformed by the measurement circuit and charge amplifier to produce an electrical output that is proportionate to the applied force. The first material used as a piezoelectric was quartz crystals. Numerous artificial crystals, including piezoelectric single crystals, have been created using quartz as a result of the widespread use of piezoelectric sensors.[8]

3. Bite Force Recording Devices Available:

- **T Scan system (Tekscan, Inc., South Boston, MA)**

The Tekscan Company created a computerised occlusal analysis system that was created and patented by Maness WL et al. to aid in occlusal analysis. It was created to be used as an adjunct in prosthodontics to address occlusal issues.

The first generation sensor (G1) was made of a pressure-sensitive ink grid made of mylar laminated and shaped like a dental arch. The sensor transmitted real-time relative force information and occlusal contact sequences to computer software when it was implanted intraorally and a load was applied. The information obtained is shown in two or three

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dimensions.[9]An ultra-thin, reusable sensor designed to suit the dental arch is used in a more recent model (i.e., T-scan III), which inserts into data collecting electronics.

In addition to being portable, this device also connects to a USB port. The T Scan system was examined by Lyons MF et al., who also assessed the device's precision in determining biting force.[10]As the T-scan technique only provides a small range of measurements for occlusal force and occasionally results in erroneous reproductions of occlusal contacts, it has come under fire. Uncontrolled shifts in the mandible have been observed as a result of the foil's lack of flexibility, which leads to inaccurate data. The device's sensitivity and planar resolution capacities are also insufficient, which results in inaccurate data.[11]

- **Prescale system (GC Co. Ltd, Japan)**

A computerised system for occlusal analysis, the Dental Prescale system (Dental Prescale, Fuji Film Co., Tokyo, Japan) measures and analyses biting force (N), occlusal contact area (mm2), and bite pressure (MPa). It was initially created in 1981 and has been used in a number of investigations on individuals who are totally, partly, or edentulous.

In order to concurrently capture the biting force of the entire dentition, the film is a pressure-sensitive sheet in the form of a horse shoe. The prescale system is made up of analytical tools (Occluzer FPD703; GC Corp., Tokyo, Japan) and pressure-sensitive sheets (Dental Prescale; Fujifilm Co., Tokyo, Japan). Type W sheets, which are about 800 mm thick, and Type R sheets, which are 97 mm thick, are the two different types of sheets. The 30 H and 50 H subtypes are further divided into the two sheet sorts.[12]

Each pressure-sensitive sheet is made up of many microcapsules filled with a color-forming substance sandwiched between two polyethylene terephthalate sheets. When force is applied, the microcapsules break, allowing the colour inside to flow out and chemically combine with a developer to create a red hue. Different colour densities are created depending on the amount of pressure applied. The tint of the red intensifies as the pressure rises.[13]

The participants must be sat in a natural, unsupported head position. The arch should line up with the midline of the sheet when the sheet is properly inserted into the patient's mouth. To incorporate every tooth in the mouth, care must be taken. In order to prevent the sheet from deforming, the buccal mucosa should be retracted. The user is encouraged to practise biting in cusp to fossa occlusion before participating in maximal clenching in the intercuspal position for three, five or ten seconds. A sheet is then placed between the maxillary and mandibular dental arches.

The Dental Prescale system's main benefits include the following: the capacity to compute bite force from each tooth in recordings with little occlusion disturbance; the capacity to assess bite force near to the intercuspal location; measurement of the occlusal contact area; the fact that it is more convenient and comfortable for subjects than strain gauge transducers; the fact that it is a simple procedure; and the fact that it is unaffected by temperature and humidity. The primary drawbacks are that it takes a lot of time, that continuous measurements can't be done, and that the bite force is overestimated because of some technical issues with the computerised scanning system.[14]

- **Dentoforce 2 (ITL AB, Sollentuna, Sweden)**

A metal fork equipped with a strain gauge transducer is part of the apparatus. The fork has a soft rubber coating that the subjects can bite on and position in the interocclusal space. ITL AB, Solientuna, Sweden) that is connected to the biting fork and recorder. In addition to showing an instantaneous reading when biting, the gadget may also show the measurement's minimum and maximum values. Additionally, the gadget has filters that improve the output signal's quality. Up to 1000 N of force can be measured. The fork has an 11 mm thickness (vertical height).[15]

- **IDDK (Kratos, Cotia, São Paulo, Brazil)**

Digital dynamometer IDDK has a 1000 N or 100 kg force capacity.[44]The tool can be modified to record bite forces inside the human mouth cavity. It consists of a digital display that is corded to a bite fork comprised of two metal rods with plastic discs covering them as an exterior layer. In order to measure the biting force, individuals must place the fork in between their teeth and bite down on the plastic disc. The metal rods will deviate when force is applied, producing an electrical signal that is sent to the

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display unit. The operator can record the bite force while holding the display unit in his hand.

A "set-zero" key on the gadget aids in the results obtained. Additionally, it records the peak value, which aids in recording the highest value still acquired even after the load has been removed. The device also contains a switch to choose between compression or traction modes.[17]

- **GM10 (Nagano Keiki, Japan)**

The disposable occlusal cap-shaped polyethylene tube that houses the hydraulic pressure gauge with a vinyl biting element is the basis of the GM10 force gauge. Its dimensions are 17 mm wide, 5.4 mm high, and 63.5 mm long. The device computes and digitally displays the bite force (N). This occlusal force gauge's accuracy and repeatability have already been established in the past.[18]

- **MPX 5700 (Motorola, SPS, Austin, TX, USA)**

A sensor and a tube are connected to an analogue to digital converter in this setup. A computer with monitoring software for pressure fluctuations is linked to the system. The individual is instructed to bite on this tube once it has been inserted interocclusally. The MPX 5700 pressure sensor should only be used to measure air pressure, according to the manufacturer's specifications. The bounce and lag caused by air's ability to compress would, however, make it difficult to measure bite force. Temperature fluctuations would also have a big impact. The tool has been effectively utilised in several investigations to record subjects' bite forces. [19]

- **FSR No. 151 (Interlink Electronics Inc., Camarillo, CA, USA)**

Interlink Electronics Inc. creates the force sensing resistor FSR No. 151. The sensor is a circular pressure-sensing resistor made of conductive polymers. It is constructed from two thermoplastic sheets, with the top sheet having a semi-conductive Polyetherimide ink coating and the bottom sheet having two conducting interdigitated electrodes. This sensor's primary characteristic is that it is piezoresistive, meaning that as pressure is applied, resistance lowers. The tool has been employed in numerous bite force experiments.[20]

- **MPM -3000 (Nihon, Koudenshi Co, Tokyo)**

The instrument consists of an occlusal force transducer and a digital multimeter MPM-3000 from Nihon Koudenshi Co. in Tokyo. Its end is a plate with a diameter of 17 mm, and its centre is a block with a height of 1 mm and a diameter of 3 mm. The maximal digital readouts are measured and shown in kg while the patient is told to bite on the block. The subject's teeth's occlusal surface must receive the block. [17]

- **Flexiforce (Tekscan, South Boston, MA, USA)**

A tool called Flexiforce (Tekscan, Inc., South Boston, USA) was created by Freeman PW and Lemen CA. A piezoresistive load cell and an electrical gadget for sensing changes in the sensor's resistance made up their system. The sensor's circular tip is made of a piezoresistive substance. The second component, a B2pe microcontroller (Parallax, Inc., Rocklin, California)-connected electric circuit, electronically measure changes in the sensor's resistance. Flexiforce sensors have a 4500 N force measurement range. According to Freeman PW and Lemen CA, these are affordable and simple to use. Several research have successfully employed the gadget.

4. Conclusion

In dentistry, a variety of tools and techniques have been used to measure biting force, but there hasn't been a systematic comparison of these tools. A researcher might choose a tool that best meets the objectives of his investigation after weighing its benefits and drawbacks.

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