A Review of Digital Occlusal Analysis by Bite Force Devices

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Abstract

Bite force is a crucial factor to consider when assessing the effectiveness of the masticatory system. Currently, a number of instruments are used to measure bite force, that differs in their design and operation. The majority of these devices employ force transducers. The clinicians may find it challenging to select a tool that achieves the intended result of capturing bite force. This article lists all of the tools available for measuring biting force. It serves as a guide for clinicians as they make decisions during the clinical process and also serves as a foundation for the creation of new occlusal force assessment tools.

Keywords: Bite force, transducer, devices

Introduction

The force exerted by the masticatory muscles during occlusion is said to be a bite force[1]. The masticatory system's function and integrity has a significant impact on the quality of life of a person[2]. Many interconnected factors can contribute to masticatory system dysfunction, including decay tooth, missing tooth, a discrepancy in dental arches, TMJ dysfunction, and different fractures of the mandible. As a result, the evaluation of these diseases on time is very critical for the improvement of quality of life[3]. To evaluate the masticatory system's function and efficacy, the bite force is recorded in different research for procedures such as dental prosthesis[4], and orthodontic treatment[5], to study the effects of malocclusion[6] & temporomandibular disorders[7].

In recording the bite force, a various devices with different designs and concepts are used[8]. The reduced bite force is seen in periodontal tissue loss, trauma, and TMJ disorders, moreover, an increased bite force may be seen in bruxism[9,10]. A gnathodynamometer was first invented by Borelli in 1681 to evaluate bite forces. A variety of devices are used to measure bite force. Pressure sensors are used to convert force into electrical energy in these devices, and these are strain gauge transducers, piezoresistive transducers, and pressure transducers[11]

Bite Force Recording Technique

Bite force devices can be mechanical, electrical, or a combination of both. The earlier devices were mechanically constructed. Borelli created the first such device in 1681[12]. It was known as a gnathodynamometer. Various devices were developed few were new inventions, while some were modifications of previous devices eg. The lever-spring, manometer spring and lever, and micrometer devices[13]. The majority of bite force devices now use sensitive electronic devices. Such devices give accurate and precise readings for load measuring applications. The load cells (transducers) in these devices convert force to electrical energy.

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Types of force transducers are-

Strain-Gauge Transducer

A strain gauge transducer is a device that helps in converting the measured pressure into a changed value related to resistance with the help of elastic sensitive elements and strain gauges[14]. They are made up of a metal plate or fork. It is typically used to measure higher pressures and elastic elements, and compensation resistors strain guage. These transducers are highly sensitivity and accuracy having a wide variety of measurement, are small and lightweight, and can be used in a variety of environments. After insertion of the bite fork, the subject is instructed to bite as hard as possible for 3-4 seconds[15]. Although the strain gauge transducer has been shown to accurately measure bite force, recording the true maximum bite force remains difficult. This was primarily due to the sensor's hard surface, which made the subjects feel uneasy or worried when biting it[16]. Another significant drawback is that the bite force measurement results may be affected while using a strain gauge transducer by the location of the bite fork. According to researchers, the change in readings in bite force is related to the position of the sensor and to the dental arch.

Piezoresistive Transducer

The effect associated with piezoresistance of integrated circuit technology crystal silicon is used to make piezoresistive transducer. When the force is applied to the monocrystalline silicon material, there is a change in resistivity and the output related to the electrical signal to the change in force can be found using a measuring circuit[17]. It is used because of its high sensitivity, quick dynamic response, accuracy is high, a wide range of operating temperatures, and small size. It helps to resolve the issues with strain gauge transducers by allowing the integration of resistance, compensation, and silicon chips with signal conversion circuits[18]. With less jaw separation, the occlusal forces can be measured with strain gauge transducers devices.

Pressure Transducer

In this device, the pressure of a liquid or gaseous substance is converted into signals which are electrical in nature. It consists of a fluid or air-filled chamber. The film is horseshoe-shaped which is pressure sensitive and consists polyethylene terephthalate films which are two in number and in between these various microcapsules filled with colour forming material are placed. When high pressure is placed in the chamber, it gets transmitted to the pressure gauge and values are produced. Pressure transducers are of two types i.e. pneumatic and hydraulic transducers based on the contents of the chamber[19]. Densities having different color are formed result of different pressure application. There is an increase in the red color intensity as the pressure increase. Analysis of the data should be done on the same day[20]. Compression of the colored image is done after scanning and the different readings are observed.

Bite recording devices that are commercially available include:

Device	Company	Country
Dentoforce 2	ITL AB	Sweden
IDDK	Kratos	Brazil
GM 10	Nagano Keiki	Japan
T scan	Tekscan, Inc	South Boston, MA
Prescale system	GC Co. Ltd	Japan
MPX5700	Motorola	Austin, TX, USA
FSR No. 151	Interlink Electronics Inc.	Camarillo, CA, USA
MPM -3000	Nihon, Koudenshi Co	Tokyo
Flexiforce	Tekscan	South Boston, MA, USA

1. Dentoforce 2 - ITL AB, Sollentuna, Sweden

A metal fork and a strain gauge transducer are used to make the device. The fork consists of a soft rubber coating on which subjects can bite that can be placed in the interocclusal region. The recorder is attached to the bite fork, and the force applied (in Newtons) is displayed on a digital display device (Multimeter 4055, ITL AB, Solientuna, Sweden). The device is capable of showing the minimum and maximum values, as well as an instant reading while biting. The device also includes filters that improve the quality of the output signal. The forces Can be measured up to 1000 N[21] and the thickness of the fork is around 11 mm. The subjects are instructed to bite hard for at least 3 to 4 seconds. In a different research, the device has been used successfully[22].

2. IDDK- Kratos, Cotia, São Paulo, Brazil

IDDK is an automated dynamometer that measures forces of 1000 N or 100 kg. It comprises of a bite fork consisting of pair of metal rods covered in plastic discs that is corded to an electronic display. The thickness of the fork is 14.6mm. The fork is put in the patients' mouths, and they bite down on the plastic disc to measure how hard they bite. The metal rods move when force is applied, producing an electrical signal that is relayed to the display unit. While holding the display unit in his hand, the operator can control it. The device has a "set-zero" key that enables exact management of the measured data. Additionally, the peak value is recorded, which is helpful in recoding the highest value achieved even after the load has been removed. Additionally, the device contains a switch that lets you select between the traction and compression capabilities. The operator has the option of setting the scale to N or Kgf. It includes a load cell as well as an electronic circuit that displays bite force readings on a digital LCD screen. Various researches have used IDDK successfully to measure bite force [7,23]

3. GM 10- Nagano Keiki, Japan

- The GM10 force gauge is composed of a disposable occlusal cap made of polyethylene and a hydraulic pressure gauge with a vinyl biting element. It is 63.5 mm long, 5.4 mm tall, and 17 mm wide[24]. The device calculates and displays the bite force (N) digitally[25]. Several studies have used the device successfully to record bite force in human dentition. Subjects felt no discomfort or pain while biting on the instrument[24].This device has following advantages :
- Portability
- Ease of use;
- Soft biting element that allows for secure , accurate, and recording in a comfortable manner ;
- Bite force is instantly measured digitally. The bite force is calculated and shown digitally in Newtons.

4. T scan - Tekscan, Inc., South Boston, MA

It is a computerisd system developed by the Tekscan Company and Maness WL et al. created and patent the invention[26]. It was created for use as an auxiliary in prosthodontics to correct occlusal problems[27]. The first generation sensor (G1) was made up of a mylar laminated pressure sensitive ink grid shaped like a dental arch. When the sensor was placed intraorally and a load was applied, it relayed real-time occlusal contact sequences and relative force information to computer software. The generated information is shown in two or three dimensions as either a continuous force movie or as a force snapshot of the whole occlusal contact event[27]. The T-scan III and later generations feature a super-thin (0.004 inch, 0.1 mm) and the sensor can be reused that fits into data acquisition circuitry and is designed to match the tooth arch. This portable device connects to any Windows-based laptop or computer through USB.

The main merit of T scan is its slim sensor .The T Scan technology was evaluated and tested for accuracy in determining bite force by **Lyons MF et al.**[28].

5. Prescale system- GC Co. Ltd, Japan

It is a computerised occlusal analysis system that measures and analyses bite force (N), occlusal contact area (mm2), and bite pressure (MPa). It was invented in 1981 and has since been used successfully in a variety of investigations on individuals who were edentulous, partially dentate, or dentulous patients[29,30]. The film is in the shape of a horse shoe that simultaneously captures the bite force of the complete dentition12.

Each pressure-sensitive sheet is made up of double polyethylene terephthalate films and numerous microcapsules filled with a color-forming material.

The disadvantages of this device are:

- Time-consuming ;
- Continuous evaluations are not possible
- the bite force is overestimated because of technical restrictions in the computerized system[31].

6. MPX5700- Motorola, SPS, Austin, TX, USA

A tube and a sensor are linked to an analogue to an automated converter in this system which has width of 7mm. It is linked to a computer that has pressure-reading software. Before the subject nibbles on it, this tube must be put interocclusally. It is only fit for measuring air pressure. However, because air is resilient, bounce and delay are likely to be concerned for measuring bite force. Temperature changes would also have a notable impact.

7. FSR No. 151- Interlink Electronics Inc., Camarillo, CA, USA

It is a resistor that detects force. A circular conductive polymer pressure-sensing resistor serves as the sensor. It is made up of two thermoplastic sheets: the bottom sheet has a pair of conducting electrodes, and the first layer has a semi-conductive coating. The characteristic of this sensor is that it is piezoresistive which means when pressure increases the resistance is relatively decreased. On the temperature change, the thermoplastic sheet's primary function is to shield and cover the sensor from moisture. The device has been employed in a number of studies.

8. MPM -3000- Nihon, Koudenshi Co, Tokyo

This device has a digital multimeter and a transducer. It has a 17 mm diameter plate at one end and a 1 mm high and 3 mm diameter block in the centre. The block must be placed on the occlusal surface of the teeth, and the subject must bite on it while. Majority of the digital readings are calculated and shown in Kg. Several studies[32,33] have found the device to be effective.

9. Flexiforce- Tekscan, South Boston, MA, USA

A tool called Flexiforce was created by **Freeman PW and Lemen CA**[34] for calculating bite force. A piezoresistive load cell and a computerized gadget for sensing alterations in the sensor's resistance made up their apparatus. The piezoresistive sensor was a thick strip with 150mm of height and 10 mm of width along with thickness of 0.2mm

Conclusion

It might be difficult for the clinician to pick a device that accomplishes the desired motive of measuring the bite force. As a result, this article lists the numerous tools used to measure force. It serves as a guide for clinicians as they make decisions during the treatment modality and also serves as a foundation for the creation of new occlusal force assessment tool.

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