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Design and development instrument to record biting force

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Abstract- The above mentioned description deals with a design and development of a new novel bite force recorder using solid state components is clearly explained. This state of the art authenticated device can be used to manipulate the complex function of human bite force, which is the net resultant combination of functional response of various craniomandibular structures consisting of interrelated components, like the muscles of mastication, joints, teeth and the neuromuscular system. The consistency and accuracy of the bite force recorder was reaffirmed by doing a detailed laboratory calibration and clinical testing on 20 adult subjects.

Index Terms- Bite force, Laboratory calibration

I. Introduction

Diseases or disorders of the muscles of the head and neck, with special reference to the masticatory muscles is determined by the complex and interrelated components comprising the morphology and biomechanics of the muscles, joints, teeth and the neuromuscular system .Bite forces, which greatly differ in magnitude and direction, result from different combinations of action of masticatory and cooperative muscle. Several clinical and animal experimental studies have shown the significant role played by the function of muscles of mastication in craniofacial growth. It has been shown that relatively large forces are generated when teeth are brought into occlusion and these forces decrease when the bite point is moved anteriorly. In some investigations no difference between genders was detected, whereas in others males produce greater bite force than the females. Bite force has been shown to increase with age till a specific age and then the levels start decreasing, but the cut-off age for this change is still not known. The variability of the results of bite force has often been considerable with a large number of factors influencing the value obtained have been made to investigate the so-called normal chewing forces as well as biting forces in man. Clinical evaluation of the physiologic characteristics of the muscles of mastication by means of accurately measuring the human bite forces have been studied with several types of equipment, and the maximal values reported have varied greatly. As need for improvements necessitate, so the continuing endeavor to strive for better, more refined, simpler and accurate device has led to further development in designing a device which can record human bite forces with high level of consistency and accuracy. The present study describes the design and development of a new novel bite force recorder.

Aims and Objectives

1. To develop a new, more refined, simpler and accurate bite force recorder for recording relatively large forces, which are generated when teeth are brought into occlusion?
2. To reaffirm the consistency of this bite force recorder by conducting a detailed laboratory calibration test on 30 adult subjects.
3. Selection of good elastic material for biting member
4. Meshing and finite element analysis of biting member for design, development and calibration

II. Materials and instruments used are as listed

1 Biting Member:-Stainless Steel (Grade 316)

General Properties: An alloy 316 is molybdenum-bearing austenitic stainless steels which is more resistant to general corrosion and pitting crevice corrosion than the conventional Alloy. This alloys offer higher creep, stress-to-rupture and tensile strength at elevated temperatures. In addition to excellent corrosion resistance and strength properties, the Alloys 316, 316L, and 317L Cr-Ni-Mo alloys also provide the excellent fabricability and formability which are typical of the austenitic stainless steels.

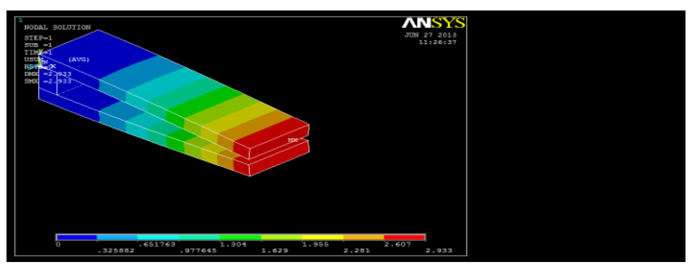

Fig 1.1: biting member ANSYS model

The above model (basically stainless-steel grade-316) has been modeled using ANSYS 11 simulation software. During modeling dimensions are chosen arbitrarily and model has been completed for simulation purpose, selected dimensions are checked for various force values and their respective deformations, from the list various values suitable dimensions has been selected, and from this suitable one is both upper and lower beam thickness is 3mm and in between there is a gap of 6mm, provided horizontal gap thickness is 42mm . For modeling **solid brick 8 node- 45** element type is chosen and various properties of stainless steel 316 grade are given during modeling, they are Young's modulus is 200000Mpa, poison's ratio 0.27. We found that for a force of up to 620N there is no

touching of both upper and lower member, consequently we can measure force up to 620-625N.
viability by following means:

2. Strain gauge (350 Ω metal wire)

While there are several methods of measuring strain, the most common is with a strain gauge, a device whose electrical resistance varies in proportion to the amount of strain in the device. For example, the piezoresistive strain gauge is a semiconductor device whose resistance varies nonlinearly with strain. The most widely used gauge, however, is the bonded metallic strain gauge. The metallic strain gauge consists of a very fine wire or, more commonly, metallic foil arranged in a grid pattern. The grid pattern maximizes the amount of metallic wire or foil subject to strain in the parallel direction (Fig1.2). The cross sectional area of the grid is minimized to reduce the effect of shear strain and Poisson Strain. The grid is bonded to a thin backing, called the carrier, which is attached directly to the test specimen.

Fig2.1: Strain gauge with wire connection

Therefore, the strain Experienced by the test specimen is transferred directly to the strain gauge, which responds with a linear change in electrical resistance. Strain gauges are available commercially with nominal resistance values from 30 to 3000 with 120, 350, and 1000 ohm. It is very important that the strain gauge be properly mounted onto the test specimen so that the strain is accurately transferred from the test specimen, though the adhesive and strain gauge backing, to the foil itself. Manufacturers of strain gauges are the best source of information on proper mounting of strain gauges

3. Three core shielded wire cable:

A shielded cable is an electrical cable consisting of one or more insulated conductors enclosed by a common conductor. The shield is usually composed of braided strands of copper. This type of cable is used to eliminate the noise which affects the signal. The shield acts as Faraday Cage to reduce the interference of electrical noises, All real time applications of strain gauges require shielded cables to connect the strain gauges to the signal conditioning circuits (Wheatstone bridge). In this work three core shielded wire of one meter length is used to connect the two strain gauges in to the bridge circuit. One end of the shield is connected to the ground.

4. Signal conditioning circuit consisting of strain gauge and Instrumentation amplifier

Strain gauges each of 1000Ω unstrained resistance are used for sensitivity; strain gauges are connected in the sensor bridge (Wheatstone bridge) as quarter bridge arrangement. The bridge is balanced for zero; this is done by using a precision multi-turn potentiometer in oneof arm of the bridge. When we apply the force on the biting member the resistance of the strain gauge increases, this produces some unbalanced bridge output on amplifier with gain of 570 is used to convert 1 kg of load in to 10mv. A digital panel meter with 0-200mv range is used as a display. In this way the digital panel meter display number and the precision weight are co-related,

5. Digital panel meter (DPM)

It is a low cost ready to use digital display and it is most popular for displaying the voltage in 0-0.2V, 0-2.0V and 0-20.0V ranges. In our project we have selected 0-2.0V range. This is because the instrumentation amplifier and Wheatstone bridge are designed in such way that the voltage produced when the maximum permissible force is applied on the biting member is within this range. The DPM consist of an 8-bit dual slope integrator ADC, a $3^1/_2$ digit 7- segment LED display and associated circuits. It is a handy and very low cost "plug and play" type display.

III. Calibration Test

Once the instrument was ready, it was calibrated with loads from 10 to 85 kg by a universal testing machine at Bureau of Indian Standards. Loads were applied through extracted natural teeth (molars) mounted in acrylic blocks to stimulate the conditions in the mouth. The reading on the DPM was noted for the various force values, and three recordings were taken for each weight. The mean of the three recordings was finally taken.It was seen that the increase in recorded mV values on DPM were proportional to increase in loads applied.

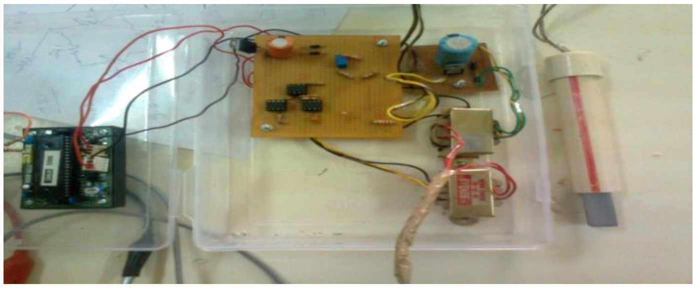

Fig5.1: Parts of biting force recorder

The patients were seated on a dental chair with head unsupported and positioned so that the Frankfort horizontal plane would be parallel to the floor. The patients were explained about the procedure and asked to bite maximally when told. The fork was placed parallel to the dental arch so that biting end was positioned in the right maxillary first molar region . At the beginning of the test, each subject was asked to bite on the fork in the order to make him familiar with the equipment and no measurements were made. After that a series of three consecutive recordings were taken and noted. The rest period of one minute was given between each recording to prevent muscle fatigue. Mean of the three recordings was taken as the maximum bite force (MBF) in the molar region (maximal intercostal position, MBFP1).

Fig 5.2: Technique for recording the maximum bite force

IV. Results

20 dental students (10 males and 10females) aged 20 to25 years volunteered as test subjects. in this study to reaffirm the accuracy in recordings of the bite force recorder.

Table1. Observations recorded of 20 subjects used for clinical testing

Subject range	Mean (without surgery)	Mean (with surgery)
Male (n=15)	615.8 N	424.24 N
Female (n=15)	488.2 N	381.75 N

V. Discussion

To evaluate clinically the physiologic characteristics of the masticatory muscles, various methods, like measurement of myoelectric activity, bite force recording and endurance test, have been used. Interest in the study of the strength of masticatory musculature dates back to the 17th century as documented by Borelli (1681) who was among the first to measure the force of mastication using a somewhat similar technique of assessing the bite force by transducers placed between one pair of opposing teeth, leaving the rest of the dentition separated. The most successful of the entire lot of bite force recorders consisted of a metallic fork, an electronic instrument, an instant standardization device and disposable caps. This forms the basis of the framework of the bite force recorder designed entirely in house by us. It has added features, like a strain gauge which was chosen because of its advantages. The total thickness of the fork with disposable caps was 11.0 mm. A similar vertical opening between jaws was produced by recorder used in several researches. Prior to measuring the bite force, the fork was calibrated by an instant standardization device which is unique to this study. To reduce metallic impact on the teeth and to prevent cross contamination, a unique and exclusive set of disposable caps were designed and used by us. The instruments were calibrated with loads from 5.0 to 90 kg by a universal testing machine .The bite force was recorded by placing the fork in maxillary first molar area has also been done in other studies and was recorded unilaterally. The human bite forces registered in this study lay within the calibration range. In some investigations, no difference between genders was detected, whereas as in others men produced greater bite forces than women. In the present investigation the difference between genders was evident in the maximal bite force recorded in the molar region. This finding is mostly due to the greater muscular potential of men. The stability of the coated housing between teeth may, therefore, partly explain the high bite force values recorded in this study.

VI. Conclusion

To conclude we can exclaim with confidence which is backed by results of our scientific study and assessment of authenticated literature that our bite force recorder is more sensitive, accurate, reproducible, compact, battery operated, hygienic due to disposable covers and has the ability to produce accurate readings in a simplified way which is very helpful and suitable for field studies as well as the clinics.

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