International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Special Issue - AMET-2019

Studies on Mouthguard Material Thickness for Minimum Energy transfer to Skull –A Review

S.B.Girase, Assistant Professor, MIT college of Engineering,Pune. shailendra.girase@mitcoe.edu.in

Prof. Dr. B.S.Kothavale, Professor, MITCOE,Pune. basavraj.kothavale@mitcoe.edu.in

S.P.Shisode , Assistant Professor, MITCOE,Pune. shailendra.shisode@mitcoe.edu.in

C.K.Patil, Assistant Professor, MITCOE,Pune. chetan.patil @mitcoe.edu.in

Abstract: Mouthguards (MG) are used to reduce injuries during contact sports. Thickness of MG material is directly related to amount of energy absorption ability and hence reduction in energy transfer to skull. Many studies had shown that Ethylene Vinyl Acetate (EVA) is best suited material for MG. Studies had been conducted on EVA material to find optimum thickness. As thickness of Material increases its Impact absorption ability is also increasing. Beyond 4 mm thickness its rate of energy absorption reduces very much, Also beyond 4 mm it is not comfortable for wearer. Studies were also conducted on inclusion of air cells in EVA material and showed that its absorption ability increases significantly. But detailed study using different materials, designs with different combinations were not conducted . So there is need to conduct studies on it

***Keywords:** Mouth guard, Mouth Protector, Ethylene Vinyl Acetate, Impact absorption, contact sports*

I. INTRODUCTION

Mouth guard is mainly used for absorbing and spreading Impact energy during sporting activities. In both contact as well as Non contact sports such as Rugby, Boxing and Basketball, there are possibilities of orofacial damage such as injuries to soft tissues and the temporomandibular joint, tooth fracture, tooth displacement, bone fracture and hence Injuries to skull. So to minimize possibilities of Injuries to skull as well as to teeth, It is necessary to wear Mouth Guard (MG). This will minimize Impact energy transfer to Skull. The impact absorption ability of a MG is believed to be proportional to its thickness . Therefore It is necessary to make MG to be sufficiently thick to prevent an Injury. There are some conflicts for thickness of MG material. To date, Minimum thickness is assumed to be equal to 2mm to 4 mm and beyond 4 mm neither there is effectiveness in terms Absorption capabilities nor it is comfortable for wearing. Also material suggested was an ethylene vinyl acetate (EVA) mouth guard with a Shore A hardness of 80.This material is having required properties such as Non-toxic, high Tear resistance, high shock absorption capabilities, sufficient molding capabilities By using Air cells in EVA material its absorption capability is increasing too much about 32%. But if MG material is reinforced with Titanium material , there is no significant difference in terms of shock absorption capacity. MG materials was been tested for impact energy absorption by using drop-ball and/or pendulum devices. Though EVA material was proved best for absorbing Impact energy, still most of researchers were agreed to improve the impact absorption ability by improving designs and developing new materials

II. MOUTH GUARD MATERIAL CHARACTERISTICS

The Clinical and physical requirements of MG materials are as follows:

1] Non-Toxicity: It should not be Toxic

2] Comfort: It should be comfortable.

3] Taste: No Taste or odor

4] forming or molding: It must have higher forming capabilities.

5] Elasticity : It must have Good elastic properties.

6] Shock absorption: It must have high shock absorption capabilities.

7] Tear resistance: It must have high tear resistance

8] Water absorption: It must have low water absorption properties as it could lead to change in dimension and loss of retention in teeth.

All these properties are there in EVA material with shore hardness of 80 and with ease of manufacture it is widely accepted by many researchers. Also EVA copolymers is capable of giving wide range of properties with Polyvinyl acetate/polyethylene ratio and filler content.[4]

ISSN : 2454-9150 Special Issue - AMET-2019

III. TESTING EQUIPMENT AND METHODS

Frontal-impact designs are much useful because their findings correlate with the high incidence rates of trauma to anterior teeth. Therefore most of researchers used Pendulum type testing equipment as like an Izod or Charpy Impact pendulum.

As shown in fig.1 Mechanical Parameters Strain, Load and acceleration were measured by using Strain Guage,Load cell and Accelerometer respectively.Resulting values were amplified by strain amplifier converted into electric voltage. Dynamic energy absorption tests were performed by allowing steel ball to fall from a predetermined height and height of Rebound were measured by means of telescope . The ball was always dropped on non impacted area . The energy of Absorption was calculated from the difference in potential energy of the ball between initial height and Rebound height and calculated by the formula as

Absorbed Energy= mg(Ho-Hi)

Where M- Mass of Ball

g- Gravitational acceleration

Ho- Initial height

Hi- Rebound height

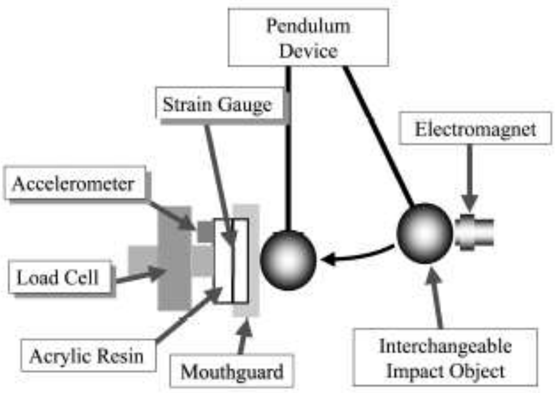

Fig. 1 Test equipment

Researchers had taken test by taking different thickness EVA material ranging from 1mm to 6 mm. Some had tested EVA with different combinations of layers of Sponge , Air cell, steel arch, Titanium wires and used different materials such as Bio-plast materials.

IV. RESULTS

As the thickness of material increases potential of material to absorb shock also increases, but further increase in thickness after 4 mm did not yield significant result from shock absorption point of view. Results of shock absorption of various thicknesses from 1mm to 6 mm were recorded and observed that beyond 4 mm , there is no much improvement in shock absorption[1],[2]

Maeda et al.[1] had taken test on steel ball and base ball i.e. Hard and soft material and observed that Steel ball shows clear results than base ball , also observed that there is no significant shock absorption beyond 4mm thick material as shown in fig.2

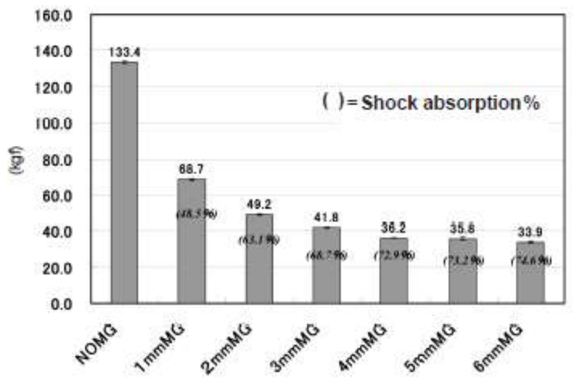

Fig.2 Impact forces and absorption abilities for steel ball

Westerman et al.[2] also got near about same results with pendulum device and using EVA material . They Observed that no significant decrease in Transmitted force after 4 mm thick EVA. Table 1 shows values of Transmitted force and Fig.3 shows its graphical representation.

Thickness (mm)	Mean Maximum Transmitted force (KN)
2	15.7
3	11.4
4	4.38
5	4.03
6	3.91

Table-1 Mean Maximum Transmitted force (KN)

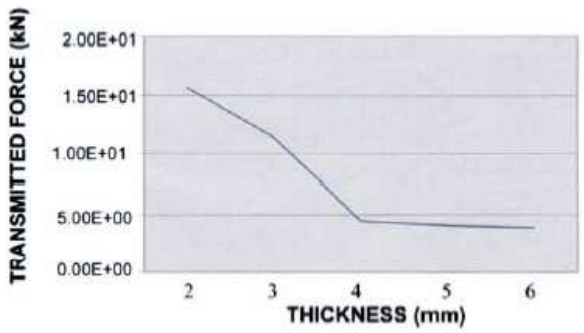

Fig 3 Mean Maximum Transmitted force (KN) and thickness (mm)

De wet et.al.[5] they had done experimentation on A pendulum-type device was used to exert force on the skull. This device enabled an impulse of the same magnitude to be exerted on a fixed skull for each type of mouth guard when the pendulum was released from a Uniform height. The principle of linear impulse Momentum was used to obtain the results. The physical principle states that the change in the linear momentum of a moving object (in this case, the modal hammer) must be equal to the impulse on the hammer had taken different combination of Materials and observed that by including sponge material layer in EVA layer gave best results of absorption of shock than by taking only EVA material or with inclusion of steel material.

Kataoka et.al.[3] had taken test on EVA material with and without Titanium wire mesh and observed that there is additional layer of Titanium did not result beneficial effect on shock absorption of Impact energy.

They prepared 20 artificial maxillae from a modified polyether-based synthetic resin to simulate teeth, jawbone and gingival. They mixed the polyether-resin with calcium carbonate and barium to replicate the hard tissue structures of the teeth, the pulp chamber contained a cellulose-based filling with additions of aniline and other organic pigments. For the bone, they used polyether-resin with an initial particle size of 0.02 mm to get a porous structure in the internal layers and a Shore hardness close to that of bone. The gingiva also was prepared of polyether-resin in a higher-viscosity mixture (15.000 centipoise) than that used to replicate bone and with a Shore hardness of A-10 on the Shore A Hardness Scale, a gauge of a material's hardness, human skin is 10 . They took silicone impressions from the individual 20 maxillae by using impression material and then cast stone models from the impressions. They produced custom-made mouth guards from the individual stone models.

V. Discussion

An improvement in the absorption energy was initially observed with an increase in the thickness. However, a further increase in the thickness from 4 mm did yield a smaller improvement in the energy absorption, This shows that from the viewpoint of the energy absorption ability only, the necessary thickness is 4 mm. Moreover, it becomes necessary to improve impact absorption by developing new materials. EVA materials are the most commonly used in the manufacture of both mouth-formed and custom-made MG. It is nontoxic and easy to use, it has become widely accepted as a MG material. However, it appears to be scope for further improvement. Materials believed to improve energy absorption by using polyolefin and polystyrene and by foaming of EVA can be used .Although these new materials are believed to result in improvement in energy absorption a detailed study remains to be performed [1]

Thicker MG were often met with wearer resistance because of discomfort from lip and cheek displacement, speech interference and respiratory restrictions. At the same time, very thin MG had well acceptance by users but were very less efficient in terms of energy absorption and transmitted forces. A number of factors play a part in the final thickness of custom-made MG. They include the fabricator's perception of correct thickness and the user's acceptance of the thickness of the manufactured MG. Also, various authorities suggests different thickness. Australian dental association suggest a thickness of 2 mm for MG[2].

This suggests that it is necessary to improve the impact absorption ability through improvements in the design of the MG. Many studies had investigated the improvement inthe impact absorption ability resulting from the use of intermediate layers or an improvement in the MG material itself. All these studies had stressed that the impact absorption ability of the MG was improved by these methods. These methods included the use of a modified 4 mm-thick EVA MG by inserting air cells, which reduced the transmission of forces by 32% as compared with the traditional EVA MG of the same thickness. A bilaminated MG with a piece of sponge as an intermediate layer, which showed the highest shock absorption as49% [1]

So there is a need for further experimentation. Many more types and designs of MG should be tested and a variety of thicknesses of materials (4-mm sheets) should be used for the manufacturing of MG. Also direction of the force of impact should be varied to assess the shock absorption potential of the various MG when the force is directed from the labial direction of the tooth instead of from the frontal direction. The exact force at the point of impact (on the labial tooth surface) should also be measured.[5]

VI. Conclusion

The study suggests that

1] EVA is best suited material for Mouth guard , also addition of layers of different material such as sponge increases its shock absorption ability

2] From the energy absorption ability point of view, the minimum thickness required to obtain sufficient energy absorption is around 4 mm, which is generally too thick from the point of view of player comfort. This finding indicates the necessity of improving the impact absorption ability of mouth guards by considering new design, different combination of materials and developing new materials.

REFERENCES

[1] M.Maeda,M.Shibhusawa,K.Takayama "In search of Necessary mouthguard thickness. Part 1: From viewpoint of shock absorption ability", J Jpn Prosthodont Soc 52: 211-219,2008 .

[2] Westerman B, Stringfellow PM, Eccleston JA, "EVA mouthguards: how thick should they be?",Dent Traumatol 2002; 18:24-27.

[3] Simony H.H.Kataoka, Frank C.Setzer,Eudes Gondim, Jr.and Celso l.Calderia, " Impact absorption and force dissipation of protective mouthguards with or without titanium reinforcement", JADA 2014; 145(9): 956-959

[4] B.M.Bishop,E.H.Devies, J.A.von Fraunhofer , "Materials for Mouth Protector" MSc. Thesis ,Institute of Dental surgery, University of London,England.

[5] Francois A.de Wet M Dent, Michiel Heyns,Johannes Pretorius, " Shock absorption potential of different mouth guard materials" , Journal of Prosthetic Dentistry, Vol.82 no.3 pp 301-306.