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# Mouth Guard for Treating Bruxism

## Abstract

Bruxism is the involuntary grinding or clenching of teeth while sleeping. It is a common dental disorder which causes wearing of the teeth and jaw pain (Nissani, 2000). The purpose of this design is to prevent bruxism and its affects on a person's teeth, muscles, and well-being. The client requires a mouth guard which has mechanical sensors to detect the patient's bruxing. The client wants this mouthguard to provide an electrical stimulus when bruxing is sensed. The stimulus will be subtle, but significant enough to cause the patient to unclench his teeth. The device will be worn at night and will have all electronics attached so that it is free standing.

## Introduction

Although the first symptoms of bruxism may only produce minor pain, once the habit is ingrained, it can cause significant damage, leading to discomfort and affecting one's quality of life. The average bruxing force between a top and bottom tooth is 300 psi (Attanasio, p.332). This force causes great pain, making it necessary not only to treat the actual grinding, but also open the jaw to relax the face muscles. Many devices have been used to alert the patient of the bruxing, attempting to "train" the person to stop. Significant research, however, proves the habit is nearly impossible to stop and that the current treatments still cause muscle fatigue (Nissani, 2000). Therefore, the motivation of this design is to create a mouthpiece which prevents the wearing of tooth enamel and stops clenching and/or grinding.

## Background

Currently, the most common model to treat bruxism is a traditional hard splint shown in Figure 1 (Nissani, 2000). This device is usually made of hard acrylic from impressions of the individual's mouth. Significant research shows that the mouth guard temporarily reduces bruxing, lowering it to about 50% of its former value (Hartmann, 1994, p.601). Although this device doesn't prevent bruxism, it will prevent damage to the teeth when bruxism occurs. However, this device fails to relax the masseter muscles (Figure 2), therefore causing side effects (Nissani, 2000).

Figure 1: Hard Splint

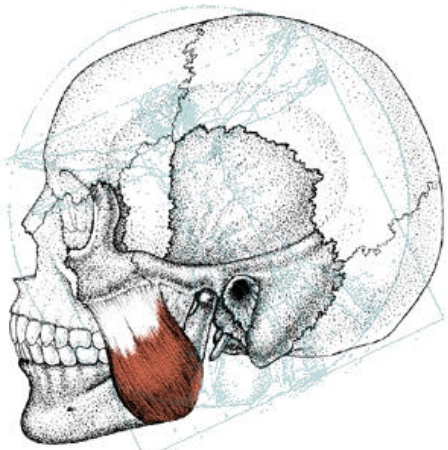


Figure 2: Inflamed Masseter muscles, due to bruxism

Other proposed treatments include psychotherapy, massed negative practice, and exercise. All of these treatments aim to reduce stress and therefore reduce teeth clenching. Although stress has been linked to bruxism, there is no evidence that indirect treatment methods have been successful (Horowitz, 1989). Direct treatments other than the traditional hard splint include a taste based model in which the patient bites down on a mouthpiece with fluid filled sacs, waking the patient as a result of bursting and releasing fluid. This, however, is not practical because frequent bruxing will cause frequent waking of the patient, further inconveniencing his lifestyle. Similarily, the patient wakes when sleep feedback devices such as sound alarms, electrical stimulation, and EMG feedback are introduced (Nissani, 2000). Our proposed design will be an improvement to these models, as long as the mouth opens in response to the electrical stimulus without waking the patient.

## Preliminary Design Ideas

The first proposed design, sketched in Figure 1 below, involved a bottom mouth guard with the electrodes attached to the side, therefore touching the cheek near the masseter muscles. This design would be similar to U.S. Patent No. 5,490,520 (Shaefer *et al.*, 1996), except would use pressure sensors that were flat and inside the upper part of the mouthguard, as opposed to the tube sensors which protrude off the mouth guard. This idea was rejected due to the large amounts of material which needed to be attached to the mouth guard, with very little room in which to do so. The tongue also poses the problem of having little space to put batteries, electrodes, and circuitry.

A second design idea would include having a device out of the mouth to detect the bruxing as opposed to a pressure sensor on the mouth guard. This would involve using a TENS machine or other similar device to administer electrical stimulus, but this time the stimulus would be outside of the mouth. There would be two electrodes attached to the outside of the cheek, as opposed to on the mouth guard. One would detect the tensing of the masseter muscles due to the clenching, and the other would administer an electrical stimulus to the masseter muscle, inducing it to relax. This design, however, would be impractical due to its excessive wires connected to an external device. While it would minimize the amount of items in the mouth, the sensors outside the mouth could be dislodged during sleep and could be hazardous, being hooked up to an external power source using wires.

A third idea included using piezoelectric sensors so that a battery didn't need to be used. A piezoelectric sensor, however, does not detect motion in more than one direction, and therefore could detect grinding but not clenching. This would not treat all types of bruxism.

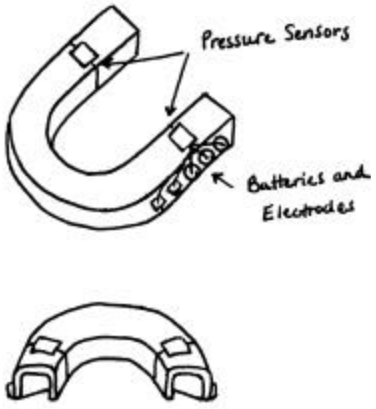



Figure 1

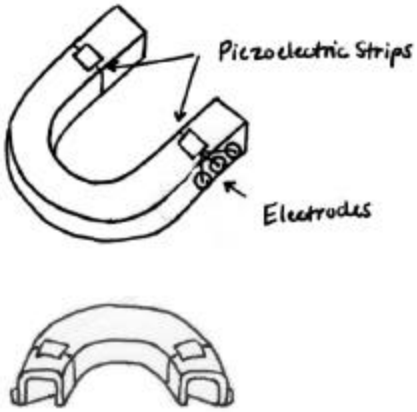



Figure 2

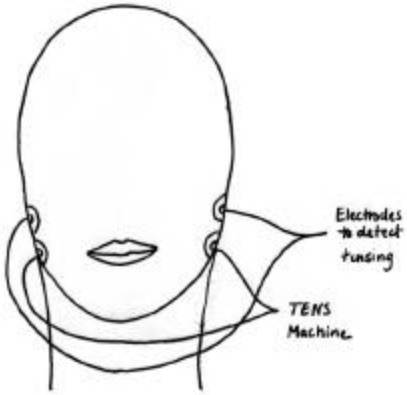


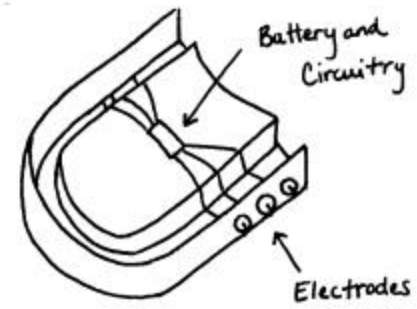

Figure 3

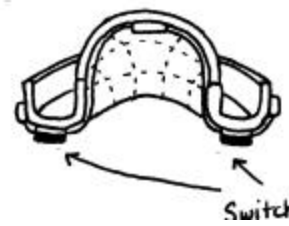
These ideas were all rejected based on their impracticality, discomfort, or ineffectiveness. The bottom mouth guard could be crowded, uncomfortable, and interfere with the tongue. The indirect method with sensors on the outside of the mouth could cause hazardous sleeping conditions and discomfort. Finally, a pressure sensor would be somewhat expensive and would require significant circuitry to determine when a certain threshold of pressure was met. Also, a piezoelectric sensor would not effectively measure all types of bruxism.

## Design

The present invention will protect the teeth from grinding by inducing the patient to open his mouth when bruxing begins. This is done through subtle electrical stimulus of the cheek which is substantial enough to induce the mouth to unclench but not to wake the patient. The device will be free standing so that the person does not have any electrical wires coming out of the mouth, nor has any sensors on the outside of the face which could be detached during sleep. It will be worn on the top teeth each night, allowing more room for circuitry and comfort (see Figure 4). The battery and connecting wires will be stored in a small compartment on the roof of the mouth. Directly touching the roof of the mouth will be a piece of plastic, molded to the specific person's mouth. The pressure of the lips against the mouthguard and the snug fit of the roof piece will hold the device in place. Underneath this will be the batteries which are then covered with a silicon rubber varnish to make it light weight, but still withstand mouth conditions, as outlined in the appendix: Product Design Specifications.

When the patient bruxes, the action will push in the switch, located on the flat, clenching surface of the mouth guard. This switch is connected to the battery on the roof of the mouth and the electrodes on the side of the mouth guard, in contact with the cheek. These wires are not imbedded in the mouth guard, but rather are placed on top, and then coated with silicon rubber. The battery will be like a watch battery and may be changeable or unchangeable, depending on the needs of the patient. The switch will close the circuit upon clenching, and will also induce the electrical stimulus (see Figure 5). The stimulus will then relax the masseter muscles, making the patient's mouth unclench, therefore stopping the bruxing.



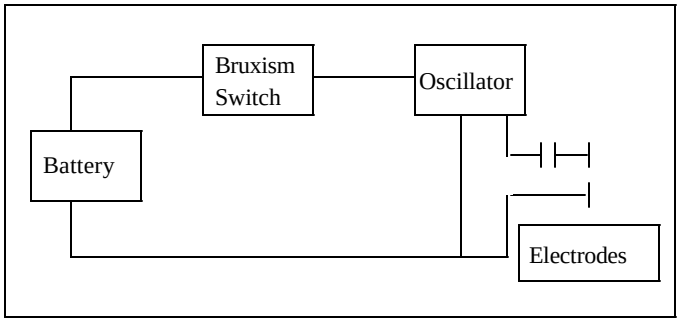




Figure 4 (left): Final design of upper mouthguard

Figure 5 (above): Circuit diagram of final design

The following is a table of the advantages and disadvantages of the different proposed designs.

| Design | Advantages | Disadvantages |
|---|---|---|
| Alternate Design 1: Bottom Mouthguard with Pressure Sensors | - Stimulation occurs at specific pressure threshold | - Pressure sensors require additional circuitry<br>- Not much room for electronics attached to outside of mouthguard |
| Alternate Design 2: Bottom Mouthguard with Piezoelectric Strips | - Power source not required<br>- Lightweight | - Piezoelectric strip can detect bruxing but not clenching |
| Alternate Design 3: External Electrodes | - Minimizes items in mouth | - Electrodes, wires could be disrupted during sleep or hazardous to patient<br>- Indirect sensing of bruxism |
| Final Design: Upper Mouthguard with Switches | - Free standing<br>- Circuitry in roof of mouth provides comfort<br>- Switches provide minimal circuitry<br>- Low maintenance<br>- Comparable cost to customized mouthguard | - Electrodes might not stimulate muscles in optimal location<br>- Stimulus may occur if the patient closed mouth without bruxing/clenching |

## Potential Problems

The main possible problem is that the electrical stimulus provided by the device may not cause the patient to unclench his teeth. This could be due to either too weak a voltage, or incorrect placement of the electrodes. Currently, the positioning of the electrodes is yet to be determined. Another possible defect is that the switch is gauged to an all-or-nothing response in which a certain threshold pressure is needed for stimulation to occur. Since patients have differing degrees of bruxism, the worst bruxers may experience constant stimulation, an effect which may be tiring on the muscles or offensive to the patient. Also, the switch may be triggered when the patient simply closes his mouth, resulting in a stimulus which is not needed. Another problem is that the electrical stimulus could be too offensive, either waking the patient, or even worse, causing pain. Since a prototype is not yet made, the exact amount of stimulus and the weight and size of the model are yet to be determined. When choosing these amounts, care must be taken to insure the patient does not experience discomfort. Finally, as is true with any mouth device, it will undergo wearing and may smell due to mouth bacteria.

## References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# Product Design Specifications:
# Mouth Guard for the Prevention of Bruxism
# 9/28/01
# Team Members: Jackie Gerhart and Darcee Nelson

**Function:** The goal of this project is to design a mouth guard that will detect the teeth grinding of a patient during sleep. The device should provide a stimulus to the patient causing he/she to unclench his/her teeth.

**Client Requirements:** Wants a mouthguard with the following:

- power source
- mechanical pressure sensors
- electrical stimulus with electrodes

**Design Requirements:**

## I Physical and Operational Characteristics

A. Performance requirements: The device will be worn by the patient while sleeping each night. Bruxism by definition, is teeth grinding during sleep.

B. Safety: The voltages must be tolerable. Any electrical equipment in the mouth must be waterproof or in a waterproof case. The device shouldn't have any small parts that could be swallowed, or sharp parts that could harm either the inside or outside skin. Device must not get too hot.

C. Accuracy and Reliability: The device has to sense whether the person is bruxing or not. To what degree they are bruxing is not monitored by this device. The device has to repeatedly indicate whether they are bruxing for the time the patient is asleep. The device should sense the bruxing with a precision of 95-100%.

D. Life in Service: The device should be able to last up to three years. This is assuming that the patient wears the device every night for 7-10 hours. The batteries may have to be changed during this time.

E. Shelf Life: The mouthguard should be kept in a cool, dry place. The shelf-life of the batteries, under zero current conditions, should be several years. The actual battery life while the patient is using the device will vary with how much the person bruxes.

F. Operating Environment: Because the device will be worn in the mouth, it should be able to withstand a wet environment. The device will also have to withstand pressures of over 300 psi (the average force exerted while bruxing), and a temperature of approximately 98.6 degrees Farenheit (body temperature.) The device will be handled by the patient who will wear the device. While the device is in storage, it may be exposed to dirt or dust if not protected by a plastic or glass case.

G. Ergonomics: The device should be comfortable and custom-made to each patient to ensure a good fit over the teeth. The patient need only put the device in his/her mouth to protect

the teeth. The device should contain a minimum amount of wires and not interfere with the patients breathing or natural sleep (when they are not bruxing.)

H. Size: The size of the device will vary, depending on the size of the patient's mouth. Typically, the diameter of the U in the mouthguard will be less than 10 cm. The thickness of the material that fits between the teeth cannot be more than 2-3 mm.

I. Weight: The device should not exceed than 10 ounces with the batteries.

J. Materials: The mouthguard should be made out of a durable plastic or hard acrylic. The electronic parts of the device will need to be coated with a silicon rubber to protect both the device and the patient.

K. Appearance: Does not need to be asthetically pleasing because it will be worn inside the mouth and not visible.

**II. Production Characteristics**

A. Quantity: If applicable, in the future this will be decided based on demand.
B. Target Production Cost: $150 dollars (custom-made)

## III. Miscellaneous

A. Patient-related concerns: The device will not have to be sterilized between uses.
B. Competition: Similar devices have patients but are not currently on the market.