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Original Research

Modified stethoscope for auscultation of temporomandibular joint sounds

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Abstract:

Background: Purpose of this study was to modify the stethoscope which can auscultate the temporomandibular joint (TMJ) sounds more precisely than conventional stethoscope, and fabrication of stethoscope compatible software which analyses the auscultated sound and gives documentary evidence of that analysis in the form of graph.

Materials & Methods: The conventional stethoscope was modified by attaching a custom made soundscope with a recording device which can be placed in external auditory meatus (EAM) for auscultation of TMJ sounds. When this small and smooth end of custom made soundscope of modified stethoscope is placed in EAM & connected with specially developed software it records the TMJ sounds & analyzes them in form of graph.

Results: Fabrication of modified stethoscope with software records the auscultated sound as a sound wave in form of graph and analyses this sound wave graph to give graphic evidence of prominent intensity at prominent frequency as spectrum analysis graph, and duration of that sound as a sound length graph.

Conclusion: The use of modified stethoscope with software increases the accuracy of auscultation of TMJ sounds without any patient's discomfort and helps in diagnosis of TMJ disorders. The modified stethoscope with software for auscultation of TMJ sounds results in more precise auscultation & analysis of TMJ for sounds even of low intensity & frequency.

Key Words: Bell, sound wave, soundscope, spectrum analysis, thud

Introduction

Mechanism of mastication is extremely complex. It is made up primarily of muscles, joints and teeth. The temporo mandibular joint (TMJ) is most complex component of masticatory system and its disorders are very common. One of the characteristic features of many patients with TMJ disorders is joint sounds. A widely used method for joint sound detection is stethoscope auscultation. Leknius & Kenyon stated that the external auditory meatus (EAM) is closest anatomically approachable structure to the TMJ, and the auditory canal has been shown to be more sensitive than surface of the skin when evaluating joint sounds.[1] Taking this into consideration the present research was planned.

Figure 1: Conventional Stethoscope.

Materials and Methods

The Stethoscope: It consists of bell chestpiece with membrane, Y- tubing and eartips. The stiffer the membrane, the higher its natural frequency of oscillation and the more efficient it is at higher frequencies. It also gives resonance to bell and the resonance of the bell amplifies the sound. The short length of tube can maximize high frequencies and still not be too short. However, 15


Figure 2: Soundscope.

inches is a good compromise between the ideal of 12 inches and the usual length of 20 to 22 inches that are commercially available. Reflected waves in the tubing may amplify sounds. Therefore, different tubing lengths may amplify different frequencies. The thicker the tube, the better is the elimination of room noise. A vinyl tube has been found to be better than rubber for this purpose. Very narrow tubes carry low frequencies best and wide tubing carries high frequencies best. An internal diameter of 3 mm was once recommended as the ideal compromise for carrying both frequencies. However, it has recently been found that 4.6 mm is even better.[2]

The greatest impairment in the efficiency of a stethoscope is the air leak. Room noise due to air leaks tends to mask high frequencies more than low once.

Fabrication of modified stethoscope

1) A stethoscope was obtained (Microtone; M. R. surgical co. India) [Figure 1].
2) Stainless steel, "soundscope" 18 mm in length and 10 mm in diameter was fabricated[3] [Figure 2].
3) The soundscope consist of a metal tube (A), stiff membrane (B), threaded metal cap (C) [Figure 3]
4) Controlling unit consisting of recording device (5mm in diameter), and multimedia cord was fabricated [Figure 4].
5) A 6 feet multimedia cord was soldered to recording device at one end; the free end of wire cord was passed through soundscope whereas the recording device was fitted in soundscope [Figure 5].
6) A stiff, 8 mm diameter membrane was cut & placed on recording device in soundscope to tighten with a threaded metal cap.[3]
7) The bell of stethoscope was removed along with its 30 mm long metal connector from Y-tubing and the screw that joins the bell to the metal connector was loosened. The free end of wire cord was passed

Figure 3: Metal tube (A), Stiff membrane (B) and Metal cap (C).


Figure 4: Controlling Unit, Recording Device & multimedia Cord.


Figure 5: Recording device fitted in soundscope.


Figure 6: Modified Stethoscope

through metal connector. Then the threaded end of metal connector was inserted into the soundscope and rotated until it was fully tightened. This whole unit was then inserted in the Y-tubing & the free end of wire cord was taken out through this at "Y" junction to connect with controlling unit [Figure 6].

Fabrication of software

Temporomandibular joint sound analyser software was developed by software engineer & was synchronized with modified stethoscope through controlling unit by means of multimedia cord.

Method of auscultation for TMJ sounds

The patient was asked to sit on dental chair in upright & relaxed position. The modified stethoscope was connected with software through connecting device by means of cord. The smooth end of the soundscope was placed into the external auditory meatus [Figure 7], after starting the software patient was asked to open his mouth slowly up to maximum opening followed by mouth closer with same speed up to maximum intercuspation to auscultate the TMJ sound if any. This records the TMJ sound if present in the form of wave graph [Figure 8]. In this way both TMJ were auscultated.

Analysis of TMJ sounds

The recorded sounds were analyzed by using tools of temporomandibular joint sound analyzer software to obtained graphs of:

1. Spectrum analysis of frequency in Hz on X-axis verses intensity in dB (decibel) on Y-axis which gives the prominent intensity in dB at prominent frequency in Hz [Figure 9].
2. Sound length in milliseconds (ms), which gives duration in ms for which that sound, occurs [Figure 10].

Figure 7: Auscultation of TMJ by modified stethoscope.

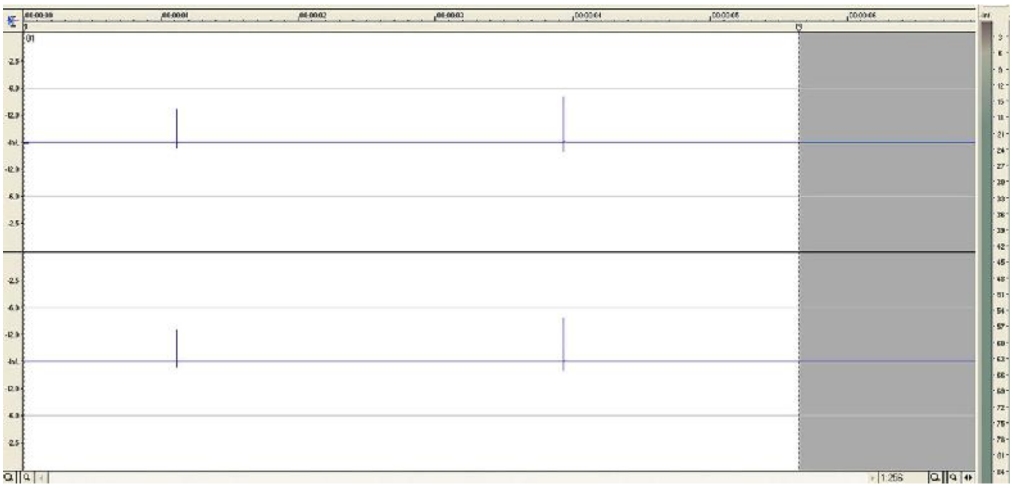

Figure 8: Sound wave graph.

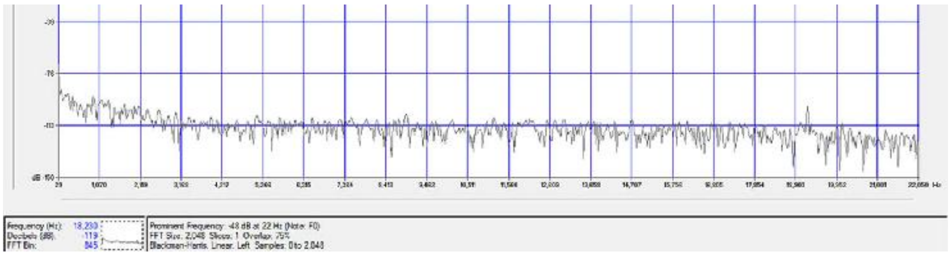

Figure 9: Spectrum analysis graph.

Figure 10: Sound length graph.

Discussion

It is realistic to assume that the more complex a system is the greater the likelihood that breakdown will occur. It is remarkable to think that in most instances it functions without major complications for the lifetime of the individual. When breakdown does occur, however, it can produce a situation as complicated as the system itself [4]

There are various commercial instruments like stethoscope, pressure algometers, sound/vibration detection devices and jaw tracking devices etc. that claim to aid in the diagnosis of various temporomandibular joint disorders. The modified stethoscope with software auscultates, records and analyzes the TMJ sounds for prominent frequency and intensity with sound length. The studies previously cited indicate that the ability to detect the presence of TMJ sounds varies from poor to excellent, depending on the technique used. The severity and nature of the click may vary from patient to patient and even within different sides in the same patient. It was documented that quantitative and qualitative analysis of the joint sounds and vibrations allows clinicians to better differentiate abnormal joints from normal joints.

Each specific disease of the TMJ was characterized by a unique relationship between the sounds propagated by the joint and the movement.[5]

There are three types of joint sounds:

a) Crepitus

This is a grating or scraping noise that occurs on jaw movement which can be noticed by the patient and often can be palpated by the clinician. It is said by the patient to feel like sand paper rubbing together. It is caused by roughened, irregular articular surfaces of the osteoarthritic joint.

b) Clicking

This is sharp & short sound caused by uncoordinated movement of condylar head and TMJ disc.

c) ***Thud***

This is dull & long sound caused by friction of two soft or wet surfaces.

Units of Sound

The standard measuring units of sound are: hertz (Hz) & decibel (dB).

Hertz is the measure of the frequency of oscillations in a wave motion. The name of the unit, hertz refers to the

German scientist Rudolf Hertz, who first proved the propagation of radio waves in 1879. The frequency is 1 Hz when one oscillation occurs in one second. When 1000 oscillations occur in one second, the frequency is 1000 Hz, or 1 kHz (kilohertz). The frequency of audible sound ranges from lowest of 16 Hz to highest frequency of 20 kHz. Sounds higher than 20 kHz are called ultrasounds, while sounds below 16 Hz are called infrasounds. In our TMJ sound analyser the frequency of sound in Hz is on X-axis of sound wave graph.

Decibel (dB) is the proportional unit of sound intensity, and the intensity of sound is sound pressure in Pascals at a given frequency in Hz. The lowest sound audible with a normal (average) hearing is 0 dB. A person with good hearing can hear even weaker sounds (-5 dB). In this TMJ sound analyser the intensity of sound in dB is on Y-axis of sound wave graph.

By comparing the obtained graphs the difference between clicking & crepitus can be observed. The clicking sound represents a sharp line with short sound length & less frequency. Whereas the crepitus type of sound represents comparatively thicker line with longer sound length & higher frequency on sound wave graph. The third term used to denote type of sound was thud, which represents a thickest line with longest sound length & highest frequency on sound wave graph.

Conclusion

The TMJ is the only joint which is directly related to the dentistry. The signs and symptoms of temporomandibular disorders are extremely common findings. Some of these appear as significant symptoms that motivate the patient to seek treatment. Many, however, are subtle and not even at a level of clinical awareness by the patient. Some subclinical signs can later become apparent and represent more significant functional disturbances if left unattended. It is therefore extremely important that each sign & symptom should be identified by means of a thorough history & examination procedure. This modified stethoscope along with software is very helpful diagnostic tool for diagnosis of TMJ disorders. Fabrication of modified stethoscope with software for auscultation of TMJ sounds results in more precise auscultation of TMJ for sounds even of low intensity & frequency. The software records the auscultated sound as a sound wave graph and analyses this sound wave graph to give graphic evidence of prominent intensity at prominent frequency as spectrum analysis graph, and duration of that sound as a sound length graph. The use of modified stethoscope with software increases the accuracy of auscultation of TMJ sounds without any patient's discomfort and helps in diagnosis of TMJ disorders.

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