Reprints from the

International Trumpet Guild® Journal

to promote communications among trumpet players around the world and to improve the artistic level of performance, teaching, and literature associated with the trumpet

Health and Awareness

Kris Chesky, Editor

New Tools for the Assessment of the Embouchure's Biomechanics

BY JAUME ROSSET I LLOBET

March 2005 • Page 51

Health and Awareness

Kris Chesky, Editor

This column will profile various health issues related to trumpet, current research activities, and existing resources available to ITG members. The following is the first in a series of reports designed to increase awareness about various organizations and associations dedicated to the health care of musicians. If you have suggestions for the column, please contact Kris Chesky, ITG Health and Awareness Editor, health@trumpetguild.org

New Tools for the Assessment of the Embouchure's Biomechanics

By Jaume Rosset i Llobet

This article was reviewed and approved for publication by the ITG Editorial Committee.

At some point during their musical career, more than 50% of wind players experience a mouth-related problem generally caused by their profession. This percentage seems high if we bear in mind that these musicians are the ones who usually run warm-ups before their daily musical routine. Even though there are multiple causes for this high percentage, we may be able to identify some main triggering factors. As for any musician, these include high physical demands, repetition of specific movements, and a very time consuming and difficult process of physical adaptation to their musical instrument. Moreover, in the case of trumpeters and other brass players, mouth-related problems are probably more common due to the sharp discrepancies between the natural physiological capacities of the lips and muscles used to form the embouchure and the physical demands imposed onto that body region during the course of musical performance.

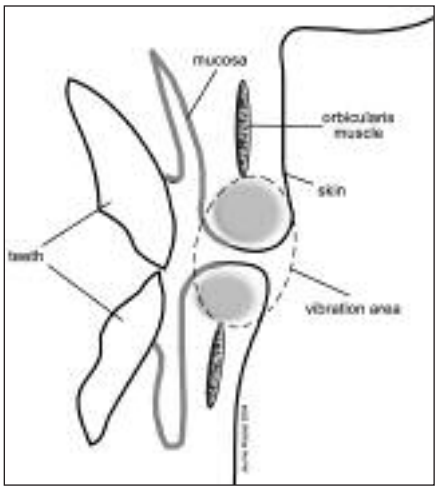

Figure 1: Lip cross-section

Lip afflictions associated with brass playing are unique and not observable in other occupational groups. Therefore, affected musicians constitute a very rare group. This may be why pathologies of the lip region are largely unknown among health care practitioners and few tools or treatment options of general value have been developed. Moreover, mouth problems are hidden by the mouthpiece during playing, making the diagnostic and evaluation process difficult for the clinician. Acoustical and biomechanical engineers, not medical doctors, have done most of the studies concerning lip behavior during the actual playing brass of instruments.

> *"...pathologies of the lip region are largely unknown among health care practitioners and few tools or treatment options of general value have been developed."*

Anatomical and mechanical aspects of sound production

During brass performance, the general mechanism allowing sound production is based on the fact that the air contained in the lungs, when pushed out by the abdominal and thoracic musculature, increases air pressure inside the mouth, eventually resulting in a gap between the lips, as well as a forward displacement of them. When the gap between the lips increases, the inner and outer pressure is equalized (*e.g.*, in the trumpet's mouthpiece). When the pressure within the vocal cavity diminishes, muscular tension, as well as tissue properties (*e.g.*, elasticity) bring the lips back to their starting position, and this closes the airflow making possible the beginning of a new cycle of vibratory behaviors. The amount of vibrating lip mass results from the interaction between the amount of air pressure being generated, the position of the tongue, the size of the vocal cavity, lip configuration, mouthpiece cup size, rim shape, muscular tension, and mouthpiece force. The quality and volume of a brass tone depend on the quality and amplitude of lip vibration, as well as the cavity size of the mouth. The throat cavity, the mouth cavity, the mouthpiece, and the brass instrument all act together as resonating chambers. There is also evidence that during music performance, the phonemic apparatus (the vocal cords, laryngeal cavity, etc.) actively contribute to the control of the airflow, to the resonance, and also to the sound quality (for more information, see http://www.phys.unsw.edu.au/~jw/brassacoustics.html).

Elements involved in lip vibration include the skin, mucous tissues, fatty tissue, and the muscles. They all play an important role in sound production. The skin, as well as the mucous tissues, not only lubricate cavities and protect from external damage but, together with the fatty tissue of the lips, contribute to the sound when the lips start to vibrate. Some of the complex face musculature hermetically closes the gaps between the lips and the mouthpiece rim, preventing air loss. In addition, these muscles produce tension in lip tissue. Depending on the amount of tension, different amounts of lip mass can be placed within the frame of the

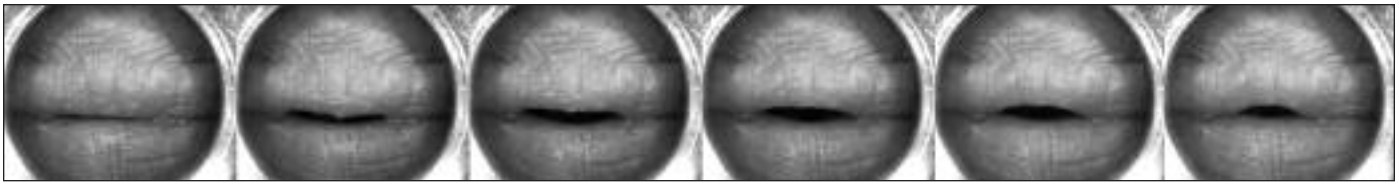

Figure 2: Videostroboscopic image of a normal single vibration cycle inside the cup

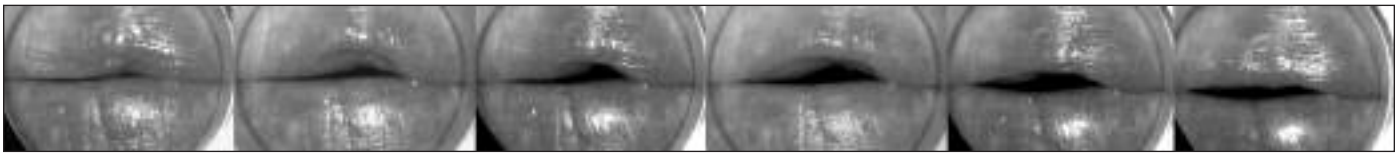

Figure 3: Stroboscopic image of a normal double vibration cycle

mouthpiece cup. The amount of air passing through the lips, and the vibratory frequency can be exquisitely regulated (Figure 1). With the help of videoestroboscopic systems (systems capable of visualizing high speed movements in real time and at high resolution), we now know that in some musicians, and under certain circumstances, a double vibration of the lips (similar to the vocal cords) occurs. This happens in the entire lip, particularly in its upper portion. The basic movement is one of closing and opening the lips combined with a swinging of inside-outside movements (See Figure 2). On the other hand, in some cases a less pronounced but important vibration can be seen. This secondary vibration affects only the skin and the mucous tissues. So far, we have seen this kind of vibration only in the upper lip. The movement is an inside-outside movement and is superimposed on the basic vibration of the lips (for images please go to http://www.institutart.com/estrobos.htm and see Figure 3).

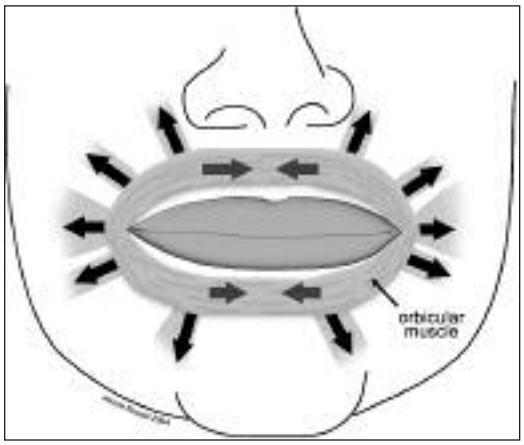

Figure 4: Muscular net of the embouchure

The vibration frequency of the lips and the mucous tissues, in other words, the tone being produced, depends most predominantly on skin, the mucous, and the fatty tissue tension. That tension is produced by the musculature surrounding the lips. They are located just below the skin and have two main functions: to open and close the eyes and the mouth, as well as to produce facial expressions. None of these functions requires a high amount of muscular effort. For that reason, only thin and delicate muscle fibers constitute that muscle group. In fact, too big of a muscular mass would impede nature's intended task. Characteristics of that kind of muscle can be studied by means high-resolution ecographs. These are machines working with high frequency waves capable of depicting superficial structures.

An advantage of this kind of non-invasive technique is that it permits the observation of moving structures. By using ecography, we can observe that the thickness of the orbicular muscle of the lip significantly augments to about three times its original size (approximately from 1 mm to 3 mm) during maximal contraction. Muscle biomechanics of the mouth region are very complex, mainly because muscles of that region do not directly attach to a bone, as is the case in other muscles of the human body. Even though some of them attach to a solid point, most of them attach to other muscles or to the skin, forming a kind of muscular net. The net terminates in the so-called *orbicularis oris* muscle, a circular muscle surrounding the mouth hole (Figure 4). However, in addition to opening and closing the mouth, brass players utilize the muscle to generate tension. For that, contraction of the numerous muscles terminating in the *orbicularis oris* is indispensable. In order to achieve a maximum efficacy on that behavior, the resulting contraction has to be symmetrical. If not, excessive tension will accumulate in specific muscular areas contributing to the potential for lesions. On the other hand, musical practice produces an adaptation to the physical demands and repetitive work on the instrument. Isolated force and resistance of the *orbicularis oris* can be reliably measured by means of force stripes which are deformed by means of muscular force. These deformations are in turn transformed into force values, which can be objectively evaluated (Figure 5). Although we bear in

> ***"...we now know that in some musicians, and under certain circumstances, a double vibration of the lips (similar to the vocal cords) occurs."***

Figure 5: TEDEL4, a system to measure force and resistance of *orbicularis oris* muscle

mind that the closing lip force is not the same as the force of the lip against the mouthpiece, the isolated action of the *orbicularis oris* is a good indication of embouchure power.

The amount of force used in different wind instruments is variable and specific to the instrument being played. For that reason, the maximum amount of force generated by an individual may be dependent on the instrument. Even when we measure variability along different parameters, we see some interesting trends in our measurements that support this hypothesis. For instance, the *orbicularis oris* muscles of single-reed instrument musicians generate an approximate maximal force of 450gr. Comparatively, musicians playing double-reed instruments generate forces up to 550gr. Brass players exert maximal forces up to 800gr. In addition, we have measured that the majority of wind players are capable of sustaining their lips' maximal force values for more than 30 seconds.

Figure 6: Videostroboscopic image showing an embouchure of a musician claiming to have gaps with air loss

Figure 7: Videostroboscopic image showing a little piece of mucous tissue interfering with the air flow

Visualization of Problems

In addition to the depiction of movement behaviors of the lips of healthy musicians, new technologies make it possible to obtain invaluable information on the origin of illnesses related to the music profession. That is also the case for wind players. For example, videostroboscopic images of the lips during sound production allow for the observation of lip vibrations. It is possible to estimate if there is a particular region of the lips behaving with excessive rigidity. Also, misdistribution of fatty tissue during sound production and contractions of the *orbicularis oris* can be easily assessed. This is important because a bad distribution of fatty tissue will produce a defective vibration. Moreover, small areas where air can flow without a complete closing phase of the vibratory sequence (See Figure 6), as well as the existence of a folding mucosa (See Figure 7), can be assessed. Both of these situations usually degrade sound production.

> ***"…the orbicularis oris muscles of single-reed instrument musicians generate an approximate maximal force of 450gr. Comparatively, musicians playing double reed instruments generate forces up to 550gr. Brass players exert maximal forces up to 800gr."***

Force measurements of the muscle *orbicularis oris* are not a definite diagnostic proof of abnormalities in the mouth region. Nevertheless, for a precise diagnosis, that kind of assessment can certainly be of great help. For example, we have found that during ruptures of the *orbicularis oris,* there is a reduction in force and resistance. The more extended the lesion, less force and resistance can be observed. On the other hand, in chronic fatigue and overuse, while the maximal force remains normal, the resistance decreases. In the case of ecographic measurements, reliability is

Continued on Page 81

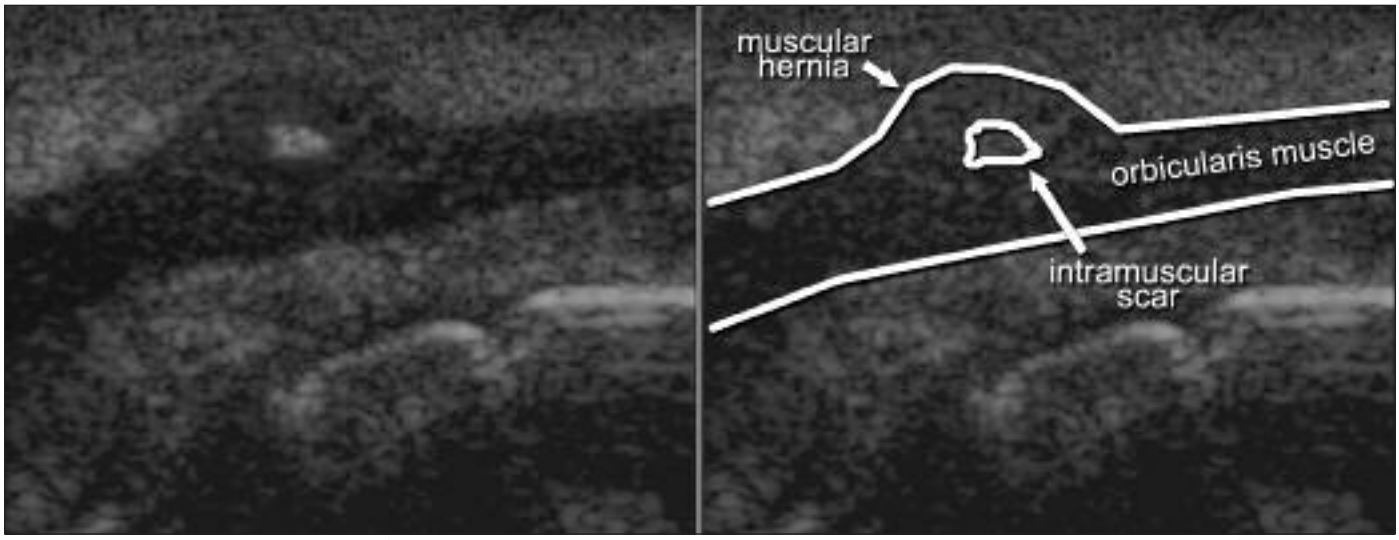

Figure 8: Ecographic image of the muscle orbicularis oris with and old muscular rupture and a residual scar (left picture: echographic image; right picture: schematic explanation of the echographic image)

ians will secure greater understanding and treatment of injuries in the future.

The author wishes to thank Dr. Victor Candia and Dr. Kris Chesky for their valuable comments during the preparation of the manuscript.

About the author: Dr. Jaume Rosset i Llobet is Arts Medicine Specialist at the Institute of Physiology and Medicine of Art-Terrassa and Director of the Science and Art Foundation, Ctra. de Montcada 668, E08227 Terrassa, Barcelona, SPAIN. For more information visit the web (http://www.institutart.com), or E-mail (info@institutart.com). Dr. Llobet will host the 11th European Congress on Musician's Medicine together with the 2nd International Congress on Musician's Medicine under patronage of the International Musician's Medicine Committee, IMMC. The meeting will convene September 16-18, 2005 in Terrassa, Barcelona (Catalonia, SPAIN). The Congress will focus on causes, diagnosis, treatment, and prevention of musician's medical problems with special attention to music pedagogy in health promotion. Main topics will include: neuroscience and music, focal dystonia, embouchure problems, muscular overuse, hand problems, and health promotion in music schools and conservatories.

Call for Papers for an Open Communication session will provide opportunities for sharing experiences and research that focus on the main topics of the Congress. Accepted abstracts, reviewed by committee, will have 10 minutes for presentation and each author can only submit one paper. Please send abstracts (300 words maximum) before March 30th, 2005 to (congress2005@institutart.com).

More information:
http://www.institutart.com/congress2005

Health and Awareness *continued from page 53*

usually not high in the absence of experience or image quality. By using a high-resolution ecograph, it is possible to obtain very good estimations of muscular quality. For example, it is possible to determine muscular thickness during maximal contractions or during relaxation. That information can be used to find slim areas in the muscle suggesting muscular elongation (where there is no rupture between fibers but longitudinal separation between them). In addition, bloody regions indicating a muscular rupture, as well as scar tissue indicative of sub-optimal physiological repair of older lesions can be uncovered (See Figure 8).

New technologies as well as advances in different domains of modern science and medicine are providing the basis to better understand different aspects of the embouchure in musician populations. Nevertheless, we are at the beginning of a much longer process of understanding. In order to succeed further in that process, a multidisciplinary approach would yield the best possibility for future progress. The further development and creation of new technologies along with an exchange of knowledge between scientists, practitioners, and professional music-