

# COMPARATIVE PERCEPTUAL EVALUATION AND ACOUSTIC VOICE ANALYSIS OF A TRANSGENDER CLIENT MALE TO FEMALE BEFORE AND AFTER LASER-ASSISTED VOICE ADJUSTMENT SURGERY

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**Abstract:** *In this study, we examined changes in the voice quality of a transgender client who had previously undergone male-to-female (MtF) transition. We conducted a longitudinal phonetic analysis after obtaining recordings from our client before and after undergoing laser-assisted voice adjustment (LAVA) surgery. The following acoustic parameters were compared: fundamental frequency (F<sub>0</sub>) measures, local jitter, shimmer, harmonic to noise ratio, phonation time, and long-term average spectrum. We assumed that the voice would not change significantly as a result of previous hormonal and vocal therapy, and that its timbre would be closer to female values after LAVA surgery.*

*Since the client was on hormone therapy before the surgery, the average values of F<sub>0</sub> corresponded to the values of a normal female voice (190.1 Hz), and, after surgery, the voice became significantly higher in phonation (235.6 Hz).*

*Before surgery, the voice was high for a male voice during reading (mean F<sub>0</sub> = 150.19 Hz for non-fricative text (NT) and mean F<sub>0</sub> = 158.06 Hz for fricative text (FT)). After surgery, the voice exhibited higher F<sub>0</sub> values (F<sub>0</sub> = 184.72 Hz for NT and F<sub>0</sub> = 191.87 Hz for FT). Before surgery, the voice was average high for a male voice during spontaneous speech (F<sub>0</sub> = 119.90 Hz), while after surgery the F<sub>0</sub> was 161.33 Hz during spontaneous speech, which is somewhat lower than the average pitch values of the female voice, but its timbral quality is more feminine. Since spontaneous speech is very important for comparison vocal timbre, we can conclude that the 42 Hz difference observed is notable.*

*Although the minimal and maximal values of F<sub>0</sub> based on phonation were significantly higher after surgery (p < 0.001), the range was limited. The total results of the F<sub>0</sub> measures are higher than expected, while the shortened phonation time points to the need for voice therapy. Considering all our results, we can conclude that it is important to discuss a client's profession before considering LAVA surgery.*

**Keywords:** *transgender; voice quality, VPA protocol, VHI, TVQ MtF, acoustic measures*

## INTRODUCTION

Studies that deal with understanding transgenderism from different perspectives sometimes provide a range of definitions for the term “transgender”. Some definitions are figurative, for example, the American Psychiatric Association (APA, 2020) and McNeill et al. (2008) reported that a transgender person is someone who temporarily or perma-

nently feels, paradoxically, that they belong to the opposite sex. Other definitions are more neutral and precise, for example, Altabas et al. (2013) defined transgenderism as a disparity between one's gender identity and their phenotypic and/or genetic sex. In the last 35 years, the concept of transgenderism has been described in published literature using a range of synonyms and terminology, including transsexuality and gender dysphoria. Although

the term “transsexual”<sup>1</sup> is more precise, when it comes to sex or gender reassignment, the *World Professional Association for Transgender Health* recommends the usage of the term “transgender” (according to Boone et al., 2019). Transsexuality is operationally defined as “a complex problem of gender identity in which the individual feels that his or her anatomic gender is the opposite of his or her psychological gender” (PEVoC07, according to Holmberg et al., 2010). According to the APA (2020), gender dysphoria<sup>2</sup> is the clash between sex (also referred to as “assigned gender”) and gender that the person (he, she, they) identifies themselves with. In other words, this term implies the discontent of the person with the gender they were assigned to at birth. Several decades ago, the term “transsexualism” was typically defined as a possible gender identity disorder (e.g., Spencer, 1988).

Based on the data available in Spencer (1988) for the United States of America, it has been determined that as many as 75-80% of all transgender people are MtF<sup>3</sup>. Similarly, data for the United Kingdom show that eight out of 100,000 people are transgender (or gender dysphoric) and that 75% of transgender people are MtF, i.e., males who wish to be perceived as females (McNeill et al., 2008; Boone et al., 2019). Also, Conron et al. (2012) stated that gender dysphoria is a very rare, and Bauer et al. (2015) found that only 0.5% of the adult population in Canada (Ontario) was transgender.

During “transition”<sup>4</sup>, the voice is one of the key components associated with the client’s adjustment and change to the other sex. Speech characteristics and timbral voice qualities are very important to clients who are in the process of undergoing gender reassignment. Changes in voice that occur during this process typically manifest as changes in the fundamental frequency ( $F_0$ ) and tonal range, moving in the direction that is desirable and characteristic of the target sex. Hormone replacement therapy and vocal cord surgery can result in a decrease or

increase in the mass, tension, and length of the vocal cords. During the change from female to male sex, androgen therapy increases the mass of the vocal cords, which makes vocal therapy significantly easier and simpler than in the case of MtF transition (McNeill et al., 2008). It is well known that estrogen therapy (used in MtF transitions) does not completely influence the feminization of vocal qualities, since it does not cause any biological changes to the size of the vocal tract; the length of the male larynx, and the relationship between the vocal cavities and the vocal cords remain the same. Therefore, in order to gain a female voice and female voice qualities, the client must undergo surgery and/or vocal therapy. The goal of any vocal educator (speech therapist, phonetician/vocal coach) is to help transgender individuals acquire a healthy voice with the vocal, paralinguistic, and behavioural characteristics of the target gender.

The  $F_0$  is a very important acoustic cue that provides more information about the speaker’s gender identity (Coleman, 1973; Spencer, 1988). Other studies have highlighted the importance of measuring the vocal tract and the relationship between the  $F_0$  and the fourth formant (F4) (Varošaneć-Škarić 1999; 2005; 2019). Therefore, in our study, we will compare  $F_0$  and F4 measurements on the basis of phonation in speech, because these measurements can provide a more complete picture of the overall quality of the voice;  $F_0$  gives us an understanding of the laryngeal function, while F4 can help us understand vocal timbre during speech.

Vocal cord surgery raises the  $F_0$  in transgender individuals. However, it should be stressed that voice pitch is not the only parameter that determines female voice quality. Mount & Salmon (1988) showed that, in MtF transgender individuals, female voice quality can be achieved by applying a more frontal pronunciation during which the mass of the tongue is shifted forward; this is acoustically manifested as a higher value of the second

1 According to the APA, a transsexual person is one who wishes to undergo or has undergone the social change from MtF or vice versa (<https://www.psychiatry.org/patients-families/gender-dysphoria/what-is-gender-dysphoria>, last accessed: February 20th 2020 ). In many, but not all cases, this also includes a physical change through hormone replacement therapy and genital surgery.

2 The term “gender dysphoria” is most frequently used in diagnostics.

3 Spencer (1988) uses the abbreviation “MTS” to indicate MtF transsexuals.

4 In this case, the term “transition” refers to the period of gender adjustment, which begins with hormone therapy (endocrinological examination) after determining gender dysphoria (psychological and psychiatric examination) (Altabas et al., 2013). Typical hormone therapy during MtF transition includes estrogen and testosterone blockers.

formant (F2). On the other hand, another study determined that MtF transgender voices that are more whispery are connected to the female voice quality, which is softer and quieter (Andrews & Schmidt, 1997). Higher vocal variability, which manifests itself as bigger shifts in loudness, rate, pitch, and intonation patterns, can also influence the perception of female voice quality (Wolfe et al., 1900). Gorham-Rowan & Morris (2006) also showed that the most successful voices, or voices with the highest female quality, were those created through heightened laryngeal tension and incomplete closure of the vocal cords corresponding to higher values of  $F_0$ ; this can be achieved through laser-assisted voice adjustment (LAVA) surgery.

### Quality of life

During their transition, transgender individuals make various changes to their lives, including administrative (change of name and gender), health-related (hormone therapy for feminization or masculinization), non-verbal (body posture, facial expressions, gestures, clothes, hair style), and communicative changes (speech style, vocabulary). Long-term changes that occur during this process are often stressful and painful, but they finally lead to an improvement in quality of life and self-satisfaction. However, this is not always the case. Transgender women express different opinions on the quality of their lives and their voice (Hancock, 2017); this is expected since each transgender individual differs based on their characteristics, just as cisgender individuals differ.

In terms of communication, although most transgender individuals are primarily interested in observing a change in the  $F_0$  (voice pitch) of their voices, vocal therapy teaches them that there are also other aspects of verbal and non-verbal communication that can influence the perception of a certain type of voice and speech as being female or male. For example, a change in vocabulary, whispery voice, facial expressions, gestures, intonation, tonal variability, speech rate, loudness, and vowel lengthening (Boone et al., 2019). Along with intonation patterns, formant patterns, articulation, and manner of speaking are also frequently highlighted (Holmberg et al.,

2010). Therefore, it is important to recognise that changes associated with communication can occur on linguistic, speech, and non-verbal levels. The goal of this case study was to compare the acoustic measures of voice quality before and after LAVA surgery, as well as to conduct a perceptual evaluation of a self-assessment of the client's voice before and after surgery with respect to quality of life.

## METHODOLOGY

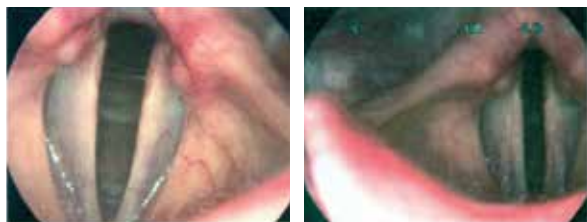
### Study subject

In 2016, a client, previously diagnosed with gender dysphoria (F64.8)<sup>5</sup>, had begun her MtF transition through hormone replacement therapy; she was 25 years old at that time. During the transition, the client had received Androcur (50 mg) and Estrofem (4 mg) on a daily basis under the supervision of an endocrinologist at the Sestre milosrdnice University Hospital Center in Zagreb. In May 2018, her therapy had been reduced to half of the original daily dose. The client is a student, native Croatian speaker, and a non-smoker. She reported that she does not consume alcohol and rarely indulges in carbonated drinks.

In May 2017, she had begun receiving vocal therapy. At this stage, it is typical to consider the data on the current occupation and future professional plans of the client: if the client planned to use their voice for artistic purposes (such as acting and singing), then the phonetician could explain that the LAVA procedure was not appropriate for them. Despite the fact that it helps the client achieve a more feminine voice, this procedure restricts pitch range and leads to poor voice timbral quality. In this case, our client was not a vocal professional, and the LAVA procedure was considered suitable.

Additionally, the client had been undergoing speech-language therapy since May 2017. This therapy was administered at the Centre for Clinical Practice and Education, Faculty of Education and Rehabilitation Sciences, University of Zagreb, where she received instructions for logopaedic exercises. Starting from May 2017, we collected audio recordings of the client at the Department of Phonetics, Faculty of Humanities and Social Sciences, University of Zagreb. As phoneticians,

<sup>5</sup> Based on WHO nomenclature, gender dysphoria (F64.8) is a subtype of other gender identity disorders (F64).



**Figure 1.** Images of the vocal cords of a transgender client before (May 2017, left) and after LAVA surgery (May 2018, right).

we were able to give vocal instructions to the client, including exercises for improving phonation time, reducing laryngeal tension with the help of impulse mild friction exercises (/s/, /š/, /h/, /f/ etc.), reducing redundant nasality, and other phonetic exercises for voice and diction (Varošanec-Škarić, 2010).

### LAVA vocal cord surgery

On April 11, 2018, the client had undergone a surgical procedure, including LAVA vocal cord surgery, thyroplasty, and rhinoplasty, where the septum and bony pyramid were reconstructed. CO<sub>2</sub> laser vocal fold vaporization during LAVA surgery (Orloff et al., 2006) often results in scarring on the vocal cords, and this is clearly visible in our client (Fig. 1). The scar tissue on the vocal cords creates a higher pitch because a reduction in the mass of the vocal cords increases their tension. Therefore, the primary purpose of LAVA vocal cord surgery was to achieve a higher voice pitch during phonation and during communication. When it comes to surgical procedures, LAVA is the least aggressive and safest procedure for clients, who are simultaneously undergoing a reduction of the laryngeal prominence (lat. Cartilago thyreoidea, also known as Adam's apple). Despite being a low-risk surgical procedure, it has been performed only three times so far on MtF individuals in the Sisters of Mercy Clinical Hospital in Croatia. One possible reason for this is the absence of a specialized centre for transgender individuals to obtain support in aspects related to their quality of life, profession, or psychological care. However, we must point out that speech therapists associated with larger clinics are willing to cooperate readily

with phoneticians. Moreover, not all transgender individuals want to visit such clinics, and the ones who do, typically visit because they wish to undergo the transition process; unfortunately, not all are eligible for the LAVA vocal cord surgery.

### Data collection

#### Speech recording

Our client was recorded in an acoustic recording studio at the Department of Phonetics in the Faculty of Humanities and Social Sciences in Zagreb. The studio was furnished with high quality acoustic equipment (AKG microphone - C414B-ULS; sound card: Fireface UFX; sampling rate: 44.1 kHz, 16 bits). The first recording was conducted in May 2017 and the second in June 2018, about eight weeks after vocal cord surgery. Both recordings included three parts and were conducted using the same methodology. Prior to the recording, the client had filled out a demographic questionnaire, and provided signed informed consent for the use of the recorded data for research purposes and for the purpose of voice quality therapy. Data collected from the client was password protected to ensure data security.

The recording process begins with the client reading two texts: a non-fricative text (Appendix 1 – T1) and another text which includes fricatives based on their frequency in the client's first language (Croatian) (Appendix 2 – T2). Based on the recordings, a long-term average speech spectrum (LTASS) is created in order to evaluate timbral voice quality at least 70 seconds of speech recording is necessary<sup>6</sup> for optimal evaluation (Škarić, 1993). LTASS is important because it represents the acoustic correlate of the perception of voice quality (Varošanec-Škarić, 2005). After the recording process, we spoke to the client in the form of an interview and asked her questions about herself, her family life, her hometown, her hobbies, and her typical day at work or studying. During this interview process, we were able to collect approximately ten minutes of spontaneous speech. This is important because our perception of gender is based primarily on spontaneous speech. At the very

<sup>6</sup> Considering that the articulation of fricatives increased the fundamental frequency, text 1 (T1) is more informative than text 2 (T2) during a vocal timbre assessment. Therefore, both T1 and T2 texts should be considered and compared when interpreting fundamental frequency.

end of the recording, the client was asked to phonate Croatian vowels<sup>7</sup> five times.

The assessment based on the perceptual descriptive phonetic protocol (Laver, 1980) and the self-assessments using the Transsexual Voice Questionnaire Male-to-Female (TVQ-MtF)<sup>8</sup> and the Vocal Handicap Index (VHI) questionnaire<sup>9</sup> were conducted before and after vocal cord surgery in order to compare the perceptual phonetic assessment and the self-assessment of the client's voice to the acoustic phonetic analysis. These assessment protocols are described in the next two sections. We agree with Orlof et al. (2006) about the importance of interdisciplinary follow-up for transgender clients who undergo LAVA surgery, and that the follow-up should include phoneticians, surgeons, speech-language pathologists, and vocal coaches. In Croatia, the vocal coaches and phoneticians, who compare the timbre and aesthetics of the voice in normal and pathological voices, are very familiar with the prosody of voice and speech and are able to apply different exercises for the improvement of voice quality and pronunciation; this is very important especially when working with vocal professionals.

### *Perceptual assessment*

Two experienced phoneticians conducted the assessment of the client's voice quality using a perceptual phonetic evaluation based on a phonetic descriptive protocol and a clinical *Vocal Profile Analysis Protocol* (VPA protocol) (Laver, 1980; 1996). According to the VPA protocol, vocal timbre can be evaluated based on the following parameters: vocal tract features, overall muscular tension, and phonation features. In an abridged version of the descriptive protocol, pitch has been described based on a scale extending from 1-5, where 1 indicates a very deep voice, 2 indicates a deep voice, 3 indicates a medium high-pitched voice, 4 indicates a high

pitch, and 5 indicates a very high pitch. Loudness of speech has been described based on a scale extending from 1-3, where 1 indicates a very quiet voice, 2 indicates a quiet voice, and 3 indicates a loud voice.

### *Self-assessment*

The client self-assessment included filling out two questionnaires: the VHI questionnaire (Jacobson et al., 1999: 66-70) adapted to Croatian by Bonetti and Bonetti (2012), and the TVQ-MtF questionnaire (Dacakis & Davies, 2012) adapted to Croatian by Bonetti (2015)<sup>10</sup> (Appendix 3). The VHI questionnaire includes 30 statements and four questions about voice condition. These statements are rated by the client on a scale from 0-4, where 0 indicates never, 1 indicates almost never (occasionally), 2 indicates sometimes, 3 indicates almost always, 4 indicates always. The VHI questionnaire has additional general questions about voice condition on the day of filling out the questionnaire; the answers include "I have no problems", "I have mild problems", "I have moderate problems", or, "I have severe problems". At the end of the questionnaire, the client rates his/her speaking ability and loudness on a scale of 1-10, where 1 is the lowest score and 10 is the highest score. Tomić and Varošanec-Škarić (2015)<sup>11</sup> tested the sensitivity of the VHI questionnaire to evaluate voice quality based on data collected from 157 speakers (93 women and 64 men) and compared several groups of vocal professionals (actors, anchors, journalists, kindergarten teachers, coaches) to a control group of younger individuals (average age of 24) who did not suffer from voice disorders. They reported good intrinsic consistency in the younger group without reported voice problems: the Cronbach alpha coefficient for the younger group was 0.93, while that of the group of vocal professionals was 0.91. The assessment of the vocal professionals showed moderate voice problems, and inter-group differences were statistically significant ( $p < 0.0001$ ).

<sup>7</sup> For the purpose of this study, five vowel [a] phonations were used in the first and second recordings.

<sup>8</sup> The TVQ MtF questionnaire was officially renamed in July 2020, and is now referred to as the Trans Woman Voice Questionnaire (TWVQ) (English version: [https://www.latrobe.edu.au/\\_\\_data/assets/pdf\\_file/0005/1146218/TWVQ-Questionnaire-English.pdf](https://www.latrobe.edu.au/__data/assets/pdf_file/0005/1146218/TWVQ-Questionnaire-English.pdf); authorized Croatian translation: [https://www.latrobe.edu.au/\\_\\_data/assets/pdf\\_file/0019/1146124/TWVQ-Croatian-Authorised-Translation-202000701.pdf](https://www.latrobe.edu.au/__data/assets/pdf_file/0019/1146124/TWVQ-Croatian-Authorised-Translation-202000701.pdf), last accessed: April 14th 2021).

<sup>9</sup> According to the VHI, a modified questionnaire can also be used for transgender women, for example, Hancock (1917) uses the Transgender Self-Evaluation Questionnaire (TSEQ).

<sup>10</sup> Available at [https://www.latrobe.edu.au/\\_\\_data/assets/pdf\\_file/0018/1032183/TVQ-croatian-authorized-translation.pdf](https://www.latrobe.edu.au/__data/assets/pdf_file/0018/1032183/TVQ-croatian-authorized-translation.pdf) (last visit: March 8th 2021).

<sup>11</sup> Tomić and Varošanec-Škarić (2015) was presented at the *5th International Conference of Fundamental and Applied Aspects of Speech and Language* in Belgrade, Serbia (Oct 17-18th 2015).

The TVQ-MtF questionnaire also consisted of 30 statements and was rated by the client based on a frequency scale, where 1 indicates never or almost never, 2 indicates sometimes, 3 indicates often, and 4 indicates very often or always. At the end of the questionnaire, the client was asked to rate his/her voice at that moment, and to report how his/her ideal voice would sound (very female, somewhat female, gender neutral, somewhat male, very male).

## Data analysis

### *Acoustic analysis*

The fundamental frequency measures ( $F_0$ , minimum and maximum  $F_0$ , alternative baseline (Alt Fb), baseline (Fb),  $F_0$  span) and time organization measure (duration in seconds) were calculated using a Praat script (Lindh, 2005) in Hz units and in semitones. Alt Fb and Fb measures are commonly used in forensic phonetics because of their robustness (Varošanec-Škarić, 2019), and Lindh and Eriksson (2007) suggested them as long-time measures of fundamental frequency, since they are considered to be independent of speaking style, vocal effort, and recording quality. Additionally, Bašić and Biočina (2020) suggested that these measurements are less affected by acoustical recording conditions and speaker intra-variability compared to other frequently used measures in acoustic research.

Furthermore, the measurements for local jitter (%), shimmer (dB), and *Harmonic to Noise Ratio* (dB) were also calculated. Based on these calculations, we estimated the fluctuation level of the fundamental frequency tone, its amplitude, and the amount of additional noise in the voice. Acoustic measurements, especially  $F_0$ , are important in the vocal therapy of MtF clients given their subjective experience, among other things. The real pitch of the voice does not have to correlate with the feeling of satisfaction of the person as a woman. What is important is how they see themselves, especially when it comes to speech. In other words, all individuals who have undergone MtF transition do not experience their voices in the same way. Some feel in harmony with their femininity even with low alto voices, while others are not satisfied with their level of femininity

even as high sopranos. Therefore, objective measurements also serve as a therapeutic component that can point to all aspects of voice quality, as well as to the fact that a high-pitched voice is not the most important aspect – one has to consider the manner of speaking, intonation, and phonation type.

### *Self-perceptual assessment*

The results of the VHI questionnaire were evaluated based on three categories: functional, physical, and emotional, as well as in total. Every category was assessed based on a three-degree scale: mild, moderate, and severe (total score = 120). Mild scores were represented by a mean value of 10.07 for the functional category, 15.54 for physical, 8.08 for emotional, and 33.69 for results in total. Moderate scores were represented by a mean value of 12.41 for the functional category, 18.63 for physical, 13.33 for emotional, and 44.37 for results in total. Severe scores were represented by a mean value of 18.30 for the functional category, 22.78 for physical, 20.30 for emotional, and 61.39 for results in total. The results of the TVQ-MtF questionnaire ranged between a minimum of 30 points and a maximum of 120 points.

### *Statistical analysis*

Since the client's voice was being analysed before and after LAVA surgery, the statistical significance of the acoustic results was tested. Statistical analysis was carried out in Microsoft Excel, and a parametric t-test was used for dependent samples (acoustical parameters based on phonation). Besides inferential statistics, descriptive statistics were reported for measures of fundamental frequency: mean, median<sup>12</sup>, minimum, maximum, and standard deviation of  $F_0$ , alternative baseline and baseline of fundamental frequency.

## RESULTS AND DISCUSSION

### **Auditory phonetic voice assessment**

Two experienced phoneticians descriptively assessed our MtF client's voice prior to the LAVA procedure, and reported that the voice was high for

12 Median values were used in statistical analysis in the present study, because they are more robust than mean values; Also, median and standard deviation values give us a better representation of the distribution of results. Since mean values are often used in acoustic phonetic research, we included it in the present study.

a male voice (4), medium high to deep tone for a female voice (3 – 2), had medium loudness (2), had a slight tremble, was nasal, and was a modal voice with remarkably low pitch for a female voice. Two months after LAVA surgery, the voice was assessed with respect to female voices, and the phoneticians reported that the voice was high (4), had a limited range of tone, was a modal falsetto (periodic, tight, very high in phonation (5)), and had a decreased range of loudness.

### Self-assessment of the voice (VHI, TVQ-MtF)

#### *TVQ-MtF questionnaire*

Based on our findings and the opinion of a speech therapist, during her first visit to the speech therapist (in 2017), the client assessed her own voice as gender neutral (value 72 in the TVQ-MtF questionnaire). About a year later (in 2018), after having received speech therapy and counselling about how to use her voice on an everyday basis, the client assessed her voice as slightly female (value 58 in the TVQ-MtF questionnaire). About 20 months after LAVA surgery (January 2019), the client assessed her voice once again as slightly female, but with a significant shift in the value scale (36 in the TVQ-MtF questionnaire). At the same time after surgery, during a counselling session with a phonetician, the client stressed that an ideal voice for her would be one that has distinctly female characteristics.

In relation to the reference values of vocal disorder levels according to the VHI scale, before the LAVA procedure, our client assessed her disorder as moderate on the functional scale (score 14) and mild on the emotional scale (score 9), and as mild in total; the post-operative scores did not show any vocal disorders based on any of the scales, or

results in total. Mc Neill et al. (2008) also reported mild vocal disorder based on the emotional scale in a large number of MtF clients before undergoing LAVA surgery. Considering that the TVQ-MtF questionnaire is adapted precisely to MtF transgender individuals, it is expected that it would be more sensitive as a data collection tool. It is clear that before LAVA surgery our client felt that her disorder was moderate (score 58) within the dimensions that represent the quality of life influenced by one's voice (see Table 1). Although the client believed that her disorder was mild after the LAVA procedure (score 36 in total), she stressed that she had always experienced a limited pitch range, that her voice sounded slightly female at the moment ("The pitch range of my speaking voice is restricted "= 4 (always)), and that, based on her total self-assessment, she would like her ideal voice to be highly female. Self-assessment of the severity of one's disorder is important for during client follow-up, because being satisfied with one's voice relates to the satisfaction with one's life, due to functional, social, and emotional factors (Oates & Dacakis, 2015). On the other hand, we noticed that self-assessments of voice pitch are not always aligned with objective measures, but also depends on the client's personality.

### Acoustic analysis

#### *Results based on vowel phonation (in Hz and in semitones (St))*

Acoustic data based on the phonation of the vowel [a] is associated with laryngeal function before and after surgery. Therefore, it is expected that the average values of  $F_0$  are higher during phonation than during reading. Since our client had undergone hormone therapy even before surgery, the total average mean values of  $F_0$  and the median

**Table 1.** Values of the VHI score and TVQ-MtF score before and after the LAVA procedure

| VHI scale             |                     |  |                |
|-----------------------|---------------------|--|----------------|
|                       | Reference values    | Before                                 | After          |
| <b>Functional (F)</b> | 10.07, 12.41, 18.30 | 14 (SD = 1.3); moderate disorder level | 9 (SD = 1.36)  |
| <b>Physical (P)</b>   | 15.54, 18.63, 22.78 | 14 (SD = 0.78); none                   | 7 (SD = 1.11)  |
| <b>Emotional (E)</b>  | 8.08, 13.31, 20.30  | 9 (SD = 0.64); slight disorder         | 3 (SD = 1.04)  |
| <b>Total</b>          | 33.69, 44.37, 61.39 | 37 (SD = 0.98); slight disorder        | 19 (SD = 0.98) |
| TVQ-MtF scale         |                     |  |                |
| <b>TVQ-MtF total</b>  | maximum 120         | 58; moderate disorder                  | 36             |

$F_0$  values based on five phonations of the vowel [a] correspond to the values of a normal female voice (mean: 182.0 Hz; median: 190.1 Hz; Table 2). After surgery, the voice exhibited a very high pitch during phonation (mean  $F_0 = 235.7$  Hz; median  $F_0 = 235.6$  Hz). A difference of 53.7 Hz in the mean value of  $F_0$  and of 45.5 Hz in the median during phonation before and after surgery are considered to be substantial. According to Spencer (1988), the boundary for categorizing a voice as female during speech is 165 Hz and higher, while the lower boundary for a voice being strongly perceived as female would be 159 Hz. It has been shown that voices below 160 Hz are perceived as male, and those higher than that as female ( $r = 0.93$ ). According to Gorham-Rowan and Morris (2006), the smallest  $F_0$  range necessary for a voice to be perceived as female is between 155 Hz and 165 Hz.

Data collected on the average basic value ( $F_b$  - average of lower phonations calculated on the basis of the median) are higher after surgery (before  $F_b = 146.3$  Hz; after  $F_b = 231.9$  Hz; in semitones: before  $F_b = 85.68$ ; after  $F_b = 94.3$ ). Therefore, based on the shift in the median value of  $F_0$  and in the average most usual frequencies during phonation, we can conclude that the values after surgery are definitely high and show the characteristics of a high female voice. If we compare the average minimal values of  $F_0$  before and after vocal cord surgery, we will see that the values before surgery are expected to correspond to a male voice (81.0 Hz), and, after surgery, they rose over an octave. The average minimal values (226.9 Hz) are also very high, even for female voices. This would be the value expected for an average female voice, and not for the minimal value of  $F_0$ . If, however, we compared the maximal value of  $F_0$  before and after surgery, we will see that they do not differ greatly; here the difference is around 30 Hz (see Table 2). During the phonation of the vowel [a], even the semitones show a significantly smaller range after surgery (1.9 St) (see Table 3). In other words, after surgery there is a minor statistically significant difference between the average minimal ( $p < 0.001$ ) and maximal values  $F_0$  ( $p < 0.001$ ), which leads to a smaller  $F_0$  range after surgery compared to before the procedure. Statistically significant differences in the measurements of  $F_0$  before and after surgery

were observed in the mean  $F_0$ , median  $F_0$ , minimal and maximal value, and in the  $F_b$  ( $p < 0.001$ ). Unfortunately, the phonation time was unsatisfactory even before surgery, amounting to an average of 15s, which could also be explained by the client's long-term hormone therapy. Two months after surgery, the phonation time was two times lesser because of the airflow in one part of the vocal cords. This should be specifically addressed during vocal therapy. Varga and Bonnetti (2016) emphasise that medical history, the client's vocal abilities, vocal usage information, and medicament therapy should be considered when administering vocal therapy for transgender clients.

The exercises for voice and diction administered by the phoneticians are based on two principles: 1) speaking is an autonomous activity, and 2) speaking is an organized activity. Since speaking is an autonomous activity, exercises should be directly connected to speaking and preparing voice organs for speaking. Since speaking is an organized activity, it requires consistent sensory control because sensory organs related to speech perform well when they are focused. The purpose of these exercises include removing laryngeal hyperkinesis, achieving phonation, optimizing pitch and timbre, and improving precise diction (Varošaneć-Škarić, 2010).

These results confirm why phoneticians are cautious when they suggest that clients could undergo laser vocal cord surgery. This is important because one of the consequences of surgery is a shortened  $F_0$  range, as well as a smaller range of loudness after the procedure and partial airflow in the gap, which is undesirable for clients who are vocal experts, since their work, such as acting or singing, requires a greater  $F_0$  range. In the present study, the client was not a vocal professional, so her profession required only regular interpersonal communication between several interlocutors at smaller distances and in spaces without external sources of noise.

Other factors calculated on the basis of the  $F_0$  measures of the aperiodicity of the tone are jitter (in %) and intensity (i.e.) shimmer (in dB), and the harmonic-noise ratio (HNR in dB). There is a minor significant difference before and after surgery based on the measure of aperiodicity of  $F_0$ , in the jitter ( $p < 0.05$ ), even though the value before



**Table 2.** Average values of  $F_0$  measurements based on the sustained phonation of [a] (Hz) and phonation time (s) before and after the LAVA procedure

| BEFORE | Mean $F_0$ | Median $F_0$ | SD $F_0$ | Min $F_0$ | Max $F_0$ | Range $F_0$ | Alt_ $F_b$ | $F_b$ | Duration (s) |
|--------|------------|--------------|----------|-----------|-----------|-------------|------------|-------|--------------|
| [a] 1  | 179.3      | 184.2        | 20.5     | 86.1      | 198.9     | 112.8       | 171.4      | 150.0 | 8.5          |
| [a] 2  | 183.7      | 189.0        | 22.1     | 93.6      | 203.9     | 110.3       | 180.8      | 152.2 | 12.2         |
| [a] 3  | 189.9      | 192.1        | 13.9     | 66.4      | 258.4     | 192.0       | 187.6      | 170.1 | 16.8         |
| [a] 4  | 184.5      | 192.6        | 28.8     | 65.1      | 212.4     | 147.3       | 98.3       | 143.3 | 17.6         |
| [a] 5  | 172.6      | 192.7        | 39.8     | 93.6      | 216.4     | 122.9       | 96.9       | 115.8 | 20.1         |
| Total  | 182.0      | 190.1        | 25.0     | 81.0      | 218.0     | 137.1       | 147.0      | 146.3 | 15.0         |
| AFTER  | Mean $F_0$ | Median $F_0$ | SD $F_0$ | Min $F_0$ | Max $F_0$ | Range $F_0$ | Alt_ $F_b$ | $F_b$ | Duration (s) |
| [a] 1  | 236.8      | 236.6        | 2.3      | 227.2     | 246.0     | 18.9        | 234.1      | 233.5 | 9.6          |
| [a] 2  | 237.4      | 237.3        | 2.2      | 228.5     | 247.0     | 18.5        | 234.5      | 234.3 | 7.9          |
| [a] 3  | 233.0      | 232.8        | 2.2      | 228.6     | 245.1     | 16.5        | 230.3      | 229.8 | 7.8          |
| [a] 4  | 233.1      | 232.8        | 2.3      | 228.1     | 239.8     | 11.6        | 229.9      | 229.8 | 7.1          |
| [a] 5  | 238.4      | 238.5        | 4.6      | 221.8     | 290.9     | 69.1        | 234.7      | 231.9 | 4.8          |
| Total  | 235.7      | 235.6        | 2.7      | 226.9     | 253.8     | 26.9        | 232.7      | 231.9 | 7.4          |

**Table 3.** Average values of  $F_0$  measurements based on the sustained phonation of [a] (semitones) and t-test results before and after the LAVA procedure

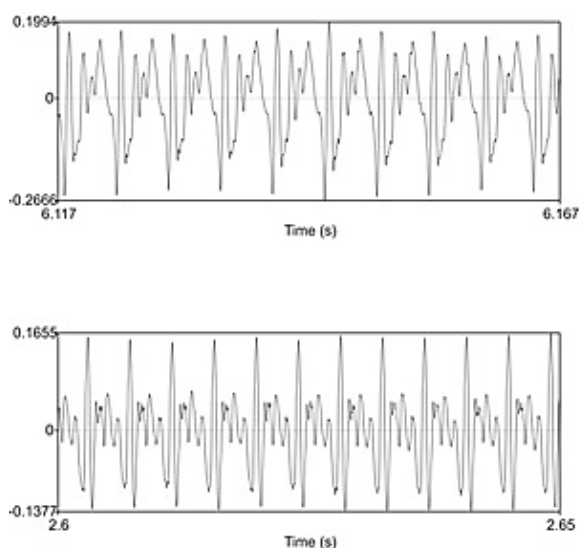
| BEFORE | Mean $F_0$ | Median $F_0$ | SD $F_0$ | Min $F_0$ | Max $F_0$ | Range $F_0$ | Alt_ $F_b$ | $F_b$     |
|--------|------------|--------------|----------|-----------|-----------|-------------|------------|-----------|
| [a] 1  | 89.7       | 90.3         | 2.6      | 77.1      | 91.6      | 14.5        | 89.1       | 85.9      |
| [a] 2  | 90.1       | 90.8         | 2.8      | 78.6      | 92.1      | 13.5        | 90.0       | 86.1      |
| [a] 3  | 90.8       | 91.0         | 1.7      | 72.6      | 96.2      | 23.5        | 90.6       | 88.3      |
| [a] 4  | 90.0       | 91.1         | 3.8      | 72.3      | 92.8      | 20.5        | 79.4       | 84.5      |
| [a] 5  | 88.6       | 91.1         | 4.9      | 78.6      | 93.1      | 14.5        | 79.2       | 81.6      |
| Total  | 89.8       | 90.8         | 3.2      | 75.8      | 93.1      | 17.3        | 85.3       | 85.7      |
| AFTER  | Mean $F_0$ | Median $F_0$ | SD $F_0$ | Min $F_0$ | Max $F_0$ | Range $F_0$ | Alt_ $F_b$ | $F_b$     |
| [a] 1  | 94.7       | 94.6         | 0.2      | 93.9      | 95.3      | 1.4         | 94.5       | 94.4      |
| [a] 2  | 94.7       | 94.7         | 0.2      | 94.0      | 95.4      | 1.3         | 94.5       | 94.5      |
| [a] 3  | 94.4       | 94.4         | 0.2      | 94.0      | 95.3      | 1.2         | 94.2       | 94.1      |
| [a] 4  | 94.4       | 94.4         | 0.2      | 94.0      | 94.9      | 0.9         | 94.1       | 94.1      |
| [a] 5  | 94.8       | 94.8         | 0.3      | 93.5      | 98.2      | 4.7         | 94.5       | 94.3      |
| Total  | 94.6       | 94.6         | 0.2      | 93.9      | 95.8      | 1.9         | 94.3       | 94.3      |
| t-test | p < 0.001  | p < 0.001    | p > 0.05 | p < 0.001 | p < 0.001 | p > 0.05    | p < 0.05   | p < 0.001 |

surgery was characteristic of normal voice quality (see Table 4). It should be mentioned that all three measures showed values characteristic of a normal voice before and after vocal cord surgery. The jitter was significantly reduced, which could be interpreted by the fact that in a tight voice, fluctuations can be minimal. This can clearly be seen in the oscillogram taken after surgery, which shows the complete characteristics of a modal falsetto (Fig. 2). Unfortunately, the phonation time reduced as a consequence of surgery (airflow in the back of the gap). The HNR results remained the same, indi-

cating a healthy, normal voice before and after surgery; however, this could partly be influenced by voice therapy.

### Acoustic measurements based on speech

Before surgery, our client's voice during reading was high for a male voice (non-fricative text T1: mean  $F_0$  = 150.19 Hz, median  $F_0$  = 151.49 Hz; fricative text T2: 158.06 Hz and 159.15 Hz). After the procedure, it exhibited higher values of  $F_0$  (T1: mean  $F_0$  = 184.72 Hz, median  $F_0$  = 183.96 Hz; T2: 191.87 Hz and 191.70 Hz) (see Table 5 and 6),



**Figure 2.** Voice oscillogram of a transgender individual before (upper picture) and after LAVA surgery (bottom picture).

**Table 4.** Jitter, shimmer, HNR values, along with *t*-test results before and after surgery

| BEFORE | Jitter (%) | Shimmer (dB) | HNR (dB)   |
|--------|------------|--------------|------------|
| [a] 1  | 0.611      | 0.248        | 21.12      |
| [a] 2  | 0.350      | 0.164        | 26.11      |
| [a] 3  | 0.192      | 0.113        | 26.74      |
| [a] 4  | 0.372      | 0.324        | 22.25      |
| [a] 5  | 0.628      | 0.431        | 20.61      |
| Total  | 0.431      | 0.256        | 23.366     |
| AFTER  | Jitter (%) | Shimmer (dB) | HNR (dB)   |
| [a] 1  | 0.21       | 0.283        | 22.84      |
| [a] 2  | 0.23       | 0.286        | 22.88      |
| [a] 3  | 0.15       | 0.176        | 23.95      |
| [a] 4  | 0.17       | 0.176        | 24.07      |
| [a] 5  | 0.24       | 0.231        | 24.81      |
| Total  | 0.20       | 0.2304       | 23.71      |
| t-test | $p < 0.05$ | $p > 0.05$   | $p > 0.05$ |

indicating a medium high female voice. During spontaneous speech, the client's voice before surgery was medium high for a male voice (mean  $F_0 = 119.90$  Hz, median  $F_0 = 110.74$  Hz), and after surgery was somewhat lower than the average pitch of female voices, but more like a female voice in timbre (mean  $F_0 = 161.33$  Hz, median = 160.26 Hz). Since spontaneous speech is very important for a timbral comparisons, we can conclude that the difference in the median  $F_0$  of around 50 Hz

is significant. Post-operative timbral convergence towards a female voice with medium values of mean  $F_0$  and median  $F_0$  also highlights the importance of the difference that occurred in spontaneous speech in the average basal value ( $F_0$ ) and the average of lower tones, which were notably higher after surgery (before: 85.68 Hz and after: 121.4 Hz), i.e., values of around 35 Hz higher than before (see Table 7). The  $F_0$  range remained approximately the same as before surgery during reading, while acquiring higher values in spontaneous speech because of the high average values of the maximal  $F_0$ , which were characteristic of a falsetto voice (as high as 335.15 Hz). Therefore, after surgery the voice became tighter due to the shortening of the vocal cords, which lead to the production of generally higher tones, including the maximal values. The figures showing the long-term average speech spectrum reveal the timbral differences before and after LAVA surgery in spontaneous speech (Fig. 3) and during reading (Fig. 4). There has been a shift in the distribution of spectral energy in the lower frequency region of spectrum, in the voluminous region (0 – 300 Hz), in the region from 400 to 800 Hz, in the medium high region of the spectrum, in the regions of sonority (800 – 2000 Hz) and brilliance (2.5 – 3.5 kHz), in very high regions of the spectrum, and in the strident region (from 3.5 kHz till the end of the analysed spectrum). Husson (1962) divided the higher regions of spectrum as follows: D region – brilliance (2.5 – 3.5 kHz) and E region – strident region (3.5 kHz till the end of spectrum). Usually, we analyse the speech spectrum up till 10 kHz. Škarić (1991) stratifies the brilliance region in the lower (2.5 – 3.5 kHz) and the higher subregions (3.5 – 5 kHz).

During the aesthetic voice assessment, spectral energy should be compared in the lower spectral region (up to 300 Hz), in the region of sonority (strongest amplitudes up to 2 kHz), from the region of sonority till the region of higher brilliance (2.5 kHz – 5 kHz), and in the highest region in the spectrum (from 5 kHz till the end of spectrum). During spontaneous speech, after surgery, the zone of the  $F_0$  is set to a higher frequency (shifted from a median  $F_0$  of 110.74 Hz to 160 Hz), which contributed to recognition of voice in spontaneous speech as female according to the voice pitch. Further, the

**Table 5.** Acoustic parameters before and after surgery - reading (T1, T2) and spontaneous speech (SS) in Hertz (Hz)

|                    | Mean $F_0$ | Median $F_0$ | SD $F_0$ | Min $F_0$ | Max $F_0$ | Range $F_0$ | Alt $F_b$ | $F_b$  | Duration (s) |
|--------------------|------------|--------------|----------|-----------|-----------|-------------|-----------|--------|--------------|
| <b>T1 - before</b> | 150.19     | 151.49       | 25.08    | 65.61     | 262.61    | 197.00      | 114.24    | 114.32 | 84.42        |
| <b>T1 - after</b>  | 184.72     | 183.96       | 26.80    | 66.71     | 262.17    | 195.46      | 150.74    | 146.39 | 90.54        |
| <b>T2 - before</b> | 158.06     | 159.15       | 26.72    | 66.11     | 315.37    | 249.26      | 115.38    | 119.86 | 81.72        |
| <b>T2 - after</b>  | 191.87     | 191.70       | 27.85    | 66.25     | 302.18    | 235.93      | 155.24    | 152.04 | 91.48        |
| <b>SS - before</b> | 119.90     | 110.74       | 23.93    | 69.01     | 270.84    | 201.83      | 99.45     | 85.68  | 60.89        |
| <b>SS - after</b>  | 161.33     | 160.26       | 27.92    | 65.34     | 335.15    | 269.81      | 129.75    | 121.40 | 67.41        |

**Table 6.** Acoustic parameters before and after surgery - reading (T1, T2) and spontaneous speech (SS) in semitones (ST)

|                    | Mean $F_0$ | Median $F_0$ | SD $F_0$ | Min $F_0$ | Max $F_0$ | Range $F_0$ | Alt $F_b$ | $F_b$ | Duration (s) |
|--------------------|------------|--------------|----------|-----------|-----------|-------------|-----------|-------|--------------|
| <b>T1 - before</b> | 86.51      | 86.92        | 3.05     | 72.43     | 96.44     | 24.01       | 82.03     | 82.15 |              |
| <b>T1 - after</b>  | 90.16      | 90.28        | 2.62     | 72.72     | 96.41     | 23.69       | 86.83     | 86.42 |              |
| <b>T2 - before</b> | 87.39      | 87.77        | 3.10     | 72.56     | 99.61     | 27.05       | 82.20     | 82.96 |              |
| <b>T2 - after</b>  | 90.82      | 90.99        | 2.61     | 72.60     | 98.87     | 26.27       | 87.34     | 87.08 |              |
| <b>SS - before</b> | 82.57      | 81.49        | 3.07     | 73.30     | 96.98     | 23.68       | 79.63     | 78.18 |              |
| <b>Ss - after</b>  | 87.72      | 87.89        | 3.22     | 72.36     | 100.66    | 28.30       | 84.24     | 83.12 |              |

**Table 7.** Acoustic measurements in spontaneous speech in Hertz and semitones (Hz and ST)

| Hz               | Mean $F_0$ | Median $F_0$ | SD $F_0$ | Min $F_0$ | Max $F_0$ | Range $F_0$ | Alt $F_b$ | $F_b$ | Duration (s) |
|------------------|------------|--------------|----------|-----------|-----------|-------------|-----------|-------|--------------|
| <b>SS before</b> | 119.9      | 110.74       | 23.93    | 69.01     | 270.84    | 201.83      | 99.45     | 85.68 | 60.89        |
| <b>SS after</b>  | 161.33     | 160.26       | 27.92    | 65.34     | 335.15    | 269.81      | 129.75    | 121.4 | 67.41        |
| <b>ST</b>        | Mean $F_0$ | Median $F_0$ | SD $F_0$ | Min $F_0$ | Max $F_0$ | Range $F_0$ | Alt $F_b$ | $F_b$ | Duration (s) |
| <b>SS before</b> | 82.57      | 81.49        | 3.07     | 73.3      | 96.98     | 23.68       | 79.63     | 78.18 | 60.89        |
| <b>SS after</b>  | 87.72      | 87.89        | 3.22     | 72.36     | 100.66    | 28.3        | 84.24     | 83.12 | 67.41        |

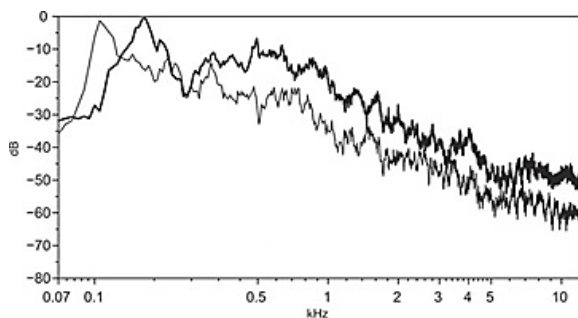
sonority region was 10 dB stronger, the spectrum showed stronger intensity in the higher zones of brilliance (10 dB stronger), and more strident to the end of the spectrum (Fig. 3). After surgery, while reading out aloud in controlled conditions, we observed a  $F_0$  shift towards higher frequency, although, it was not as notable as that observed during spontaneous speech. Intensity differences are not notable in the entire sonority region, but only around the F2 region (1.5 kHz) and in the brilliance region (stronger region of F4 and very high strident region). Slightly higher intensities in spectral regions of higher brilliance and the strident regions are expected in female voices while speaking than in male voices. Therefore, we can conclude that after LAVA surgery, the client's voice spectrum was lighter and the voice was perceived as being more feminine.

Studies have recommended that the optimal period for recording clients is between the 10<sup>th</sup> and 52<sup>nd</sup> week after LAVA surgery (Orloff et al., 2006).

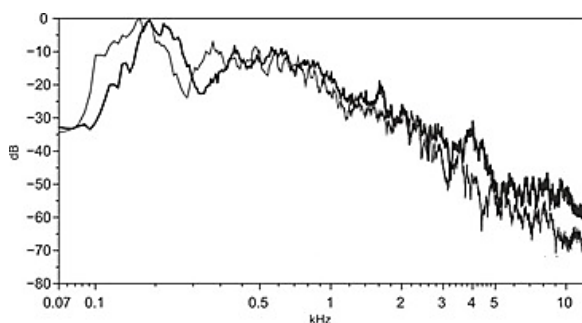
This is the time period during which the sensitivity and pain that most patients feel will reduce, after which they will establish their new permanent timbre, pitch, and other vocal parameters. Considering that the client, whose voice was analysed in the present study, went through a very brief post-operative recovery period – we assume because of her age – and that she subjectively felt that she was doing very well, we performed the acoustic recording eight weeks after the LAVA procedure.

## CONCLUSION

Laser vocal cord surgery performed using the LAVA method has proven to be highly successful in tuning the voice of a transgender patients. The reduction in the mass of the vocal cords and the increase in their tension can lead to a voice that is perceived to be female, as shown in previous studies (e.g. Orloff et al., 2006). Our study investigated the differences in the client's voice before and



**Figure 3.** LTASS of a transgender individual during spontaneous speech before (thin line) and after vocal cord surgery (thick line).



**Figure 4.** LTASS of a transgender individual during a non-fricative text reading before (thin line) and after vocal cord surgery (thick line).

after surgery by conducting an acoustic analysis (multiple measurements of the  $F_0$  in phonation and speech, LTASS representations) and using various questionnaires aimed at obtaining an expert voice evaluation and self-assessment of the client's voice (VHI, TVQ-MtF). According to the expert evaluation, after surgery, the client's voice was graded as high, with a limited tonal range, and a lowered loudness span; this was confirmed by the results of the acoustic analysis. Through the self-assessment method, the client graded her own voice as slightly female. While values obtained through the

questionnaire before surgery placed her voice in the category of moderate disorders, after surgery, it was categorized as disorder-free (with an added remark that the voice shows a limited loudness span). Based on the results of our analysis, we can conclude that the acoustic measurements proved to be an objective parameter of voice quality in the follow-up of transgender individuals during their period of transition, as well as after phono-surgical procedures.

It is important to note that the minimal and maximal  $F_0$  values based on the phonation of [a] are also significantly higher after surgery, while the  $F_0$  span remains limited. Local values of the measurements of tonal aperiodicity (jitter in %) and intensity (shimmer in dB) are somewhat lower after surgery, which is a step in the right direction. The harmonic and noise ratio of the spectrum (HNR in dB) are uniform and not pathological. The total result of the measurements of  $F_0$  during phonation and speech exceed expectations. Some can be interpreted as positive (values of the mean  $F_0$  and median  $F_0$ ), while others, such as the lowered  $F_0$  range, are considered to be an accompanying effect of laser vocal cord surgery. The latter measurement and the shortened phonation time indicate the need to continue with speech therapy and phonetic voice exercises for a longer period of time after surgery.

Finally, the questionnaires that were adapted to the Croatian language for the purpose of this study have proved to be useful in an interdisciplinary sense (for speech therapists and phoneticians/speech coaches) for the evaluation of the client's voice, as well as for her therapy during the transition period. Therefore, the results of this study show that LAVA vocal cord surgery improves the quality of life of the patient, leading to a stronger motivation to achieve their ideal female voice.

## REFERENCES

- Altabas, V., Stipančić, G., Moravek, D., Butorac, D., Žegura, I., Magaš, S. (2013). Transrodnost u Hrvatskoj: Ignorirani medicinski problem. In: Ž. Crnčević Orlić (ed.): Knjiga sažetaka, 6. hrvatski endokrinološki kongres (p.47-47).
- American Psychiatric Association (APA). Last accessed on February 20th 2020. <https://www.psychiatry.org/patients-families/gender-dysphoria/what-is-gender-dysphoria>.
- Andrews, M. L., Schmidt, C. P. (1997). Gender presentation: Perceptual and acoustical analyses of voice. *Journal of Voice*, 11, 307-313. DOI: 10.1016/s0892-1997(97)80009-4.
- Bašić, I., Biočina, Z. (2020). Metodologija akustičkih istraživanja. *Zbornik radova Filozofskoga fakulteta u Splitu*, 13, 19-40.
- Bauer, G. R., Scheim, A. I., Pyne, J., Travers, R., Hammond, R. (2015). Intervenable factors associated with suicide risk in transgender persons: a respondent driven sampling study in Ontario, Canada. *BMC Public Health*, 1-15. DOI: 10.1186/s12889-015-1867-2.
- Bonetti, A. (2015). TVQ MtF Authorised Croatian Translation. Last assessed on March 8th 2021. from [https://www.latrobe.edu.au/\\_\\_data/assets/pdf\\_file/0018/1032183/TVQ-croatian-authorized-translation.pdf](https://www.latrobe.edu.au/__data/assets/pdf_file/0018/1032183/TVQ-croatian-authorized-translation.pdf).
- Bonetti, A. (2020). TWVQ Authorised Croatian Translation. Last assessed on April 14th 2021 from [https://www.latrobe.edu.au/\\_\\_data/assets/pdf\\_file/0019/1146124/TWVQ-Croatian-Authorised-Translation-202000701.pdf](https://www.latrobe.edu.au/__data/assets/pdf_file/0019/1146124/TWVQ-Croatian-Authorised-Translation-202000701.pdf).
- Bonetti, A., Bonetti, L. (2013). Cross-Cultural Adaptation and Validation of the Voice Handicap Index Into Croatian. *Journal of Voice*, 27(1), 130.e7–130.e14. doi:10.1016/j.jvoice.2012.07.006.
- Boone, D. R., McFarlane, S. C., Von Berg, S. L., Zraick, R. I. (2019). *The Voice and Voice Therapy* (10th edition). Hoboken, New Jersey: Pearson. ISBN-13: 9780134894485.
- Conron, K.J., Scott, G., Stowell, G.S., Landers, S.J. (2012). Transgender health in Massachusetts: results from a household probability sample of adults. *American Journal of Public Health*, 102, 118–22.
- Dacakis, G., Davies, S. (2012). TVQ MtF questionnaire. Last accessed on February 20th 2020 from [http://www.shelaghdavies.com/questionnaire/TVQ\\_Questionnaire.pdf](http://www.shelaghdavies.com/questionnaire/TVQ_Questionnaire.pdf).
- Dacakis, G., Davies, S. (2020). TWVQ (formerly TVQ MtF). Last accessed on April 14th 2021 from [https://www.latrobe.edu.au/\\_\\_data/assets/pdf\\_file/0005/1146218/TWVQ-Questionnaire-English.pdf](https://www.latrobe.edu.au/__data/assets/pdf_file/0005/1146218/TWVQ-Questionnaire-English.pdf).
- Dacakis, G., Oates, J. and Douglas, J. (2017). Associations between the Transsexual Voice Questionnaire (TVQMtF) and self-report of voice femininity and acoustic voice measures. *International Journal of Communication Disorders*, 52(6), 831-838. DOI: 10.1111/1460-6984.12319.
- Dacakis, G., Oates, J. M. and Douglas, J. M. (2016). Further evidence of the construct validity of the Transsexual Voice Questionnaire (TVQMtF) using principal components analysis. *Journal of Voice*, 31(2), 142-148. DOI: 10.1016/j.jvoice.2016.07.001.
- Gorham-Rowan, M., Morris, R. (2006). Aerodynamic Analysis of Male-to-Female Transgender Voice. *Journal of Voice*, 20(2), 251-262. DOI: <https://doi.org/10.1016/j.jvoice.2005.03.004>.
- Hancock, A. B. (2017). An ICF perspective on voice-related Quality of Life of American Transgender Women. *Journal of Voice*, 31(1), 115.e1-115.e8. DOI: 10.1016/j.jvoice.2016.03.013
- Holmberg, E. B., Oates, J., Dacakis, G., Grant, C. (2010). Phonetograms, aerodynamic measurements, self-evaluations, and auditory perceptual ratings of male-to-female transsexual voice. *Journal of Voice*, 24(5), 511-552. DOI: 10.1016/j.jvoice.2009.02.002
- Husson, R. (1962). *Le chant*. Paris: Presses Universitaires de France.
- Laver, J. (1980). *The Phonetic Description of Voice Quality*. Cambridge: Cambridge University Press.
- Laver, J. (1996). *The Gift of Speech*. Edinburgh: Edinburgh University Press.

- Lindh, J. (2005-2006). Praat script. Last accessed on February 20th 2020. from <https://sites.google.com/site/phoneticolindh/home/scripts-and-audio/scripts>.
- Lindh, J., Eriksson, A. (2007). Robustness of Long Time Measures of Fundamental Frequency. INTERSPEECH 2007, 8th Annual Conference of the International Speech Communication Association, Antwerp, Belgium, August, 27-31.
- McNeill, E. J. M., Wilson, J. A., Clark, S., Deakin, J. (2008). Perception of Voice in the Transgender Client. *Journal of Voice*, 2(6), 727-733. DOI:<https://doi.org/10.1016/j.jvoice.2006.12.010>.
- Mount, K. H., Salmon, S. J. (1988). Changing the vocal characteristics of a postoperative transsexual patient: a longitudinal study. *Journal of Communication Disorders*, 21(3), 229-238. DOI: 10.1016/0021-9924(88)90031-7.
- Oates, J., Dacakis, G. (2015). Transgender Voice and Communication: Research Evidence Underpinning Voice Intervention for Male-to-Female Transsexual Women. *Perspectives on Voice and Voice Disorders*, 25(2), 48-58. DOI: 10.1044/vvd25.2.48.
- Orloff, L. A., Mann, A. P., Damrose, J. F., Goldman, S. N. (2006). Laser-Assisted Voice Adjustment (LAVA) in Transsexuals. *The Laryngoscope*, 116, 655-660. DOI: 10.1097/01.mlg.0000205198.65797.59.
- Škarić, I. (1991). Fonetika hrvatskog književnog jezika. In: R. Katičić (ed.): *Povijesni pregled, glasovi i oblici hrvatskog književnog jezika*. (p.61-376). Zagreb: HAZU and Globus.
- Škarić, I. (1993). Prosječni spektar govora kao slika boje glasa. In: Lj. Likar and D. Kosmač (eds.), *Strokovno srečanje logopedov Slovenije: Multidisciplinarni pristop v logopediji* (p. 202-205). Portorož: Portorož: Aktiv logopedov Južne Primorske.
- Spencer, L. E. (1988). Speech Characteristics of Male-to-Female Transsexuals: A Perceptual and Acoustical Study. *Folia phoniatrica et logopaedica*, 40, 31-42. DOI: 10.1159/000265881.
- Tomić, D., Varošaneć-Škarić, G. (2015). Validation of Croatian Voice Handicap Index. In: M. Sovilj and M. Subotić (eds.), *5th International Conference of Fundamental and Applied Aspects of Speech and Language* (p. 18-18). Beograd: Draslar Partner.
- Varga, A., Bonetti, A. (2016). Vokalna terapija kod transrodnih osoba. *Hrvatska revija za rehabilitacijska istraživanja*, 52(1), 114-126.
- Varošaneć-Škarić, G. (2010). *Fonetska njega glasa i izgovora*. Zagreb: FF-press.
- Varošaneć-Škarić, G. (1999). Duljina izgovornoga prolaza i uгода glasa. *Govor*, 16(2), 149-163.
- Varošaneć-Škarić, G. (2005). *Timbar*. Zagreb: FF-press.
- Varošaneć-Škarić, G. (2019). *Forenzična fonetika*. Zagreb: Ibis grafika.
- Wolfe, V., Ratusnik, D. L., Smith, F. H., Northrop, G. (1990). Intonation and fundamental frequency in male-to-female transsexuals. *Journal of Speech and Hearing Disorders*, 55, 43-50. DOI: 10.1044/jshd.5501.43.
- World Health Organization. *International Classification of Functioning, Disability and Health: ICF*. Geneva, Switzerland; 2001. Last accessed on October 15th 2020 from <https://www.who.int/classifications/icf/en/>.
- WPATH - The World Professional Association for Transgender Health. Last accessed on October 15th 2020 from <https://www.wpath.org/>.

## APPENDIX 1

### Non-fricative text for voice quality assessment

To navodi na temu o kojoj bih htio dometnuti kratak dodatak. Naime, u tim je krajevima pitanje vjere i obreda bilo u to vrijeme pitanje duhovne vladavine. To pak nije pripadalo Europi pogotovo ne Mediteranu koji je odvajkada gajio nadu i vjeru u djela velikih ljudi, u narod i more te u tvrde gradove na njegovim obalama. Mnogo godina nakon toga, mnogo je njih vjerovalo da je raj i pakao upravo u njihovom kraju. Oni koji vuku porijeklo od bijelih ljudi bili bi raj, a oni drugi koji ih odbijaju pakao. Naravno, bilo je i onih kojima je to bilo neprihvatljivo i koji nervirahu i jedne i druge jer govora da je takva predaja neutemeljena. U biti ni oni ne imahu pojma o prethodnim i davnim tokovima koji oblikuju mentalitet ovoga kraja na utoku rijeke u more. U literaturi pak nikakvih potvrda o tome nema pa i dalje treba dvojiti da je to bilo upravo tako. Na nedalekom otoku grad nije dobio ime po otoku kako je to drugdje nego obrnuto, pa je i to jedna potvrda o kulturi ljudi toga kraja.

*(This leads to the subject on which I would like comment briefly. Namely, in these parts the question of faith and ritual had at the time been a question of spiritual rule. This, however, did not belong to Europe, and certainly not to the Mediterranean, which had since always cultivated hope and faith in the work of great men, in the people, in the seas, and in the tough cities occupying its shores. Many years later, many believed that Heaven and Hell resided in their land. Those that come from white people were Heaven, while those who rejected them would be Hell. Of course, there were also those who found this to be unacceptable, and who annoyed the rest saying that this tradition was unfounded. Actually, they too had no idea about the historical and ancient paths that shaped the mentality of this land, at the place where the river reaches the sea. However, literature gives us no verification of this, which means we should still question whether it was so or not. The city on the nearby island did not get its name after the island itself, as is the case elsewhere, but the other way around, so this too should be another confirmation of the people's culture of the land.)*

## APPENDIX 2

### Fricative text for voice quality assessment

Takvi se popisi mogu složiti na mnogo različitih načina, manje ili više proizvoljnih, svatko na svojoj obali i u svome govoru; obala može neke stvari reći samo u dijalektu kojim vlada, koji je različit od onog iz unutrašnjosti i zaleđa. Dobra posada broda koja duže zajedno plovi, kadra je stvoriti vlastiti dijalekt. Uz obale, ponekad i dalje od njih, javljaju se dvostruki govori: lokalni i nacionalni. Ne znam je li tako na Istoku, a vjerujem da nije drukčije. Otok je pak posebna priča. Svaki otok ima svoj posebni dijalekt ili se pak čvrsto vjeruje da ga ima. U stvari tamo se govori mješavinom došljaka kojih uvijek ima mnogo, bilo da su prebjeci ili da su tamo došli nadajući se smirenijem i sigurnijem životu, a zapravo škrtijem i oskudnijem. Riječ mješavina tu stoji za one koji gledaju sa strane, ali za same otočane to nije tako jer se oni unutar sebe oštro razlikuju. Dijalekti im parceliraju i ograđuju ono malo čvrstoga pod nogama kao što im suhozidi omeđuju pašnjake.

*(These lists could be composed in many ways, more or less arbitrary, by anyone on their shore and in their speech; the shore can say something only by the dialect it uses, which differs from the ones in the inland and the hinterland. A good ship crew that sails together for a long time is capable of creating its own dialect. Along shores, and sometimes away from them, two spoken languages coexist: local and national. I'm not sure if it is like this in the East, but I believe it is not different. Islands are a special story though. Every island has its own dialect or it is believed that it has one. In fact, the spoken language used there is created by a mixture of languages from numerous foreign residents, regardless if they are deserters or if they moved there hoping for a quieter and safer life, but a cheaper and poorer life instead. Word mixtures remain here for outsiders, but it is different for islanders because they differ strongly from each other. These dialects parcel and surround that little piece of soil under their feet like dry stone walls surround pastures.)*

## APPENDIX 3

## TVQ-MtF questionnaire adapted to Croatian (Bonetti, 2015)

| <b>TVQ MtF</b><br>Authorised Croatian Translation   |   | <b>Skala učestalosti</b>  |                          |                          |                          |
|---|---|---------------------------|--------------------------|--------------------------|--------------------------|
|   |   | 1 = nikad ili rijetko     |                          |                          |                          |
|   |   | 2 = ponekad               |                          |                          |                          |
|   |   | 3 = često                 |                          |                          |                          |
|   |   | 4 = vrlo često ili uvijek |                          |                          |                          |
| Ime: _____  |   |                           |                          |                          |                          |
| Datum: _____  |   |                           |                          |                          |                          |
| <b>Temeljeno na vašim stvarnim iskustvima u životu kao žena, obilježite odgovor koji najbolje odgovara tvrdnji.</b>   |   |                           |                          |                          |                          |
|   |   | 1                         | 2                        | 3                        | 4                        |
| 1   | Ljudi me teško čuju u bučnoj prostoriji.  | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 2   | Osjećam anksioznost kada znam da ću koristiti svoj glas.                                | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 3.  | Zbog mog glasa, osjećam se manje ženstveno nego što bih željela.                        | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 4.  | Visina mog govornog glasa je preniska.  | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 5.  | Visina mog glasa je nepouzdana.   | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 6.  | Moj glas mi smeta da živim kao žena.  | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 7.  | Izbjegavam telefonirati zbog svoga glasa.   | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 8.  | Zbog glasa osjećam napetost kada razgovaram s drugima.                                  | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 9.  | Kada probam pričati ženskim glasom, on postaje hrapav i promukao.                       | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 10.   | Zbog glasa me teško identificiraju kao ženu.  | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 11.   | Kada govorim, visina mog glasa ne varira dovoljno.                                      | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 12.   | Zbog glasa se osjećam nelagodno kada razgovaram s prijateljima, susjedima ili rodbinom. | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 13.   | Zbog glasa izbjegavam govoriti u javnosti.  | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 14.   | Moj glas zvuči umjetno.   | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 15.   | Moram se koncentrirati da bi mi glas zvučao kako želim.                                 | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 16.   | Osjećam se frustrirano kada pokušam mijenjati svoj glas.                                | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 17.   | Teškoće s glasom ograničavaju moj društveni život.                                      | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 18.   | Kada ne obraćam pažnju, visina mog glasa se spušta.                                     | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 19.   | Kada se smijem, zvučim kao muškarac.  | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 20.   | Moj glas ne poklapa se s mojim fizičkim izgledom.                                       | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 21.   | Ulažem dosta napora kada trebam upotrijebiti svoj glas.                                 | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 22.   | Glas mi se brzo zamara.   | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 23.   | Moj glas me ograničava u poslu koji radim.  | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 24.   | Osjećam da moj glas ne odražava „pravu mene“.   | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 25.   | Manje sam otvorena zbog svoga glasa.  | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 26.   | Previše sam svjesna načina na koji nepoznate osobe doživljavaju moj glas.               | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 27.   | Glas me „izdaje“ usred govorenja.   | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 28.   | Osjećam se vrlo uznemireno kada me, zbog glasa, promatraju kao muškarca.                | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 29.   | Raspon visine mog glasa je ograničen.   | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 30.   | Osjećam se diskriminirano zbog svoga glasa.   | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>Molim vas navedite ukupnu ocjenu svoga glasa.</b>  |   |                           |                          |                          |                          |
| <b>Trenutno moj glas zvuči:</b>   |   | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
|   | Izrazito ženski   | Pomalo ženski             | Spolno neutralno         | Pomalo muški             | Izrazito muški           |
| <b>Moj idealan glas zvučao bi:</b>  |   | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
|   | Izrazito ženski   | Pomalo ženski             | Spolno neutralno         | Pomalo muški             | Izrazito muški           |
| <p>Transsexual Voice Questionnaire (Male-to-Female) © 2012, Dacakis and Davies,<br/>         Ana Bonetti, PhD, Edukacijsko-rehabilitacijski fakultet, Odsjek za logopediju Zagreb, Hrvatska (ana.bonetti@erf.hr)<br/>         Hrvatski prijevod 2015, UPITNIK ZA GLAS KOD TRANSEKSUALNIH OSOBA (TVQ<sup>TM</sup>)</p> |   |                           |                          |                          |                          |