

TWO VIDEOSTROBOKYMOGRAPHIC SOFTWARE PACKAGES FOR EVALUATING OPEN QUOTIENT OF THE VOCAL FOLDS: USER REPORT

Contributions:

A Study design/planning
B Data collection/entry
C Data analysis/statistics
D Data interpretation
E Preparation of manuscript
F Literature analysis/search
G Funds collection

Paulina Krasnodebska^{1ABCDEF}, Agata Szkielkowska^{1,2DEG}

¹ Audiology and Phoniatics Clinic, Institute of Physiology and Pathology of Hearing, Warsaw, Poland;

² Audiology and Phoniatics Faculty, Fryderyk Chopin University of Music, Warsaw, Poland.

Corresponding author : Paulina Krasnodebska, Audiology and Phoniatics Clinic, Institute of Physiology and Pathology of Hearing, 05-830 Kajetany, Mokra str. 17, Warsaw, Poland. E-mail: p.krasnodebska@ifps.org.pl

Abstract

Introduction: Laryngovideostroboscopy (LVS) is the gold standard in diagnosis of the larynx, but the interpretation of the tool is highly dependent on the examiner's competence and knowledge. An objective measure of LVS, so far used only subjectively, provides a tool for precise diagnosis of laryngeal diseases.

Aim: The aim of the study was to test two different types of videostrobokymographic (VSK) software – Divas and DiagnoScope. We also compared measures of Open Quotient obtained using the two programs.

Material and Method: 23 LVS recordings from a group of euphonic people were analyzed with Divas software (Xion Medical) and DiagnoScope Specialist software (DiagNova Technologies).

Results: The mean age in the study group was 41.1 years (women: 39.6; men: 42.4). The mean OQ_{VSK} value averaged from all three parts of the glottis measured by Divas was 0.519 and by DiagnoScope, 0.517. A Student t-test showed no significant differences between the parameters. For all measurements, absolute differences were less than 0.18. In 50% of patients, the differences in measurements did not exceed 0.05 and in 87%, 0.1. The largest differences were observed in the anterior part of the vocal folds.

Conclusions: The average values of OQ_{VSK} measurements are comparable despite the use of different measurement software. Software available on the market with a VSK module requires fine-tuning to limit the recording analysis time as much as possible.

Key words: laryngostroboscopy, kymography, vocal folds

DOS PAQUETES DE SOFTWARE DE VIDEO-ESTROBO-QUIMOGRAFÍA QUE EVALÚAN EL COCIENTE DE ABERTURA DE LOS PLIEGUES VOCALES: INFORME DEL USUARIO

Resumen

Introducción: La laringo-video-estroboscopia (LVS) forma una prueba estándar dentro de los métodos de evaluación de la laringe. La interpretación de la prueba es altamente dependiente de las competencias y la experiencia del examinador. La posibilidad de objetivar la LVS, hasta ahora considerada como un método subjetivo, ofrece una herramienta que permite realizar un diagnóstico más preciso de las enfermedades de la laringe.

Objetivo: El objetivo del trabajo fue comparar los paquetes de software de valoración video-estrobo-quimográfica (VSK): Divas y DiagnoScope. Además, se compararon resultados de los cocientes de abertura (OQ, *Open Quotient*) como parámetros calculados por ambos programas.

Materiales y métodos: Se analizaron 23 grabaciones de LVS de personas sin trastornos de la voz utilizando los programas Divas (Xion Medical) y DiagnoScope Specialist (DiagNova Technologies).

Resultados: La media de la edad del grupo analizado fue de 41,1 años. Entre las mujeres: 39,6, entre los hombres: 42,4. El valor promedio del OQ_{VSK} promediado para tres partes de la glotis medido por el programa Divas fue de 0,519 y por el programa DiagnoScope, 0,517. La prueba t de Student no demostró diferencias estadísticas entre los parámetros obtenidos mediante los dos métodos. El valor absoluto de todas las mediciones fue de hasta 0,18. En un 50% de los pacientes la diferencia entre los métodos no superó el 0,05 y en un 87%, el 0,1. Las diferencias más importantes concernían a los parámetros medidos en la parte anterior de la glotis.

Conclusiones: Los valores de OQ_{VSK} calculados por los distintos paquetes de software de análisis quimográfico son comparables. Los módulos de valoración video-estrobo-quimográfica requieren mejoras para optimizar el tiempo necesario para realizar el análisis.

Palabras clave: laringo-estroboscopia, quimografía, pliegues vocales

ДВА ВИДА ПРОГРАММНОГО ОБЕСПЕЧЕНИЯ ДЛЯ ВИДЕОСТРОБОКИМОГРАФИИ, ОЦЕНИВАЮЩИЕ КОЭФФИЦИЕНТ ОТКРЫТИЯ ГОЛОСОВЫХ СКЛАДОК: МНЕНИЕ ПОЛЬЗОВАТЕЛЯ

Резюме

Цель: Целью работы было сравнение программного обеспечения для видеостробоскопической оценки (VSK): Divas i DiagnoScope. Кроме того, проведено сравнение результатов коэффициентов открытия (OQ) – параметров, рассчитывающихся с помощью обеих программ.

Материал и метод: Мы проанализировали 23 записей LVS лиц без нарушений голоса с помощью программного обеспечения Divas(XionMedical) и DiagnoScopeSpecialist (DiagNova Technologies).

Результаты: Средний возраст в анализируемой группе составил 41.1 лет. Среди женщин – 39.6, среди мужчин – 42.4. Средняя величина OQ_{VSK} , усреднённого из трёх частей голосовой щели, измеренная программой Divas, составила 0.519, а DiagnoScope – 0.517. Тест t-Student не показал статистических различий между параметрами, полученными в обоих методах. Абсолютное значение всех измерений составило до 0.18. У 50% пациентов различие между методами не превышало 0.05, а у 87% 0.1. Самые большие различия касались параметров, измеренных в передней части голосовой щели.

Выводы: Значения OQ_{VSK} , рассчитанные разными программами для кинематографического анализа, сопоставимы между собой. Модули для видеостробоскопической оценки требуют доработки с целью оптимизации времени, необходимого для анализа.

Ключевые слова: ларингостробоскопия, кинематография, голосовые складки

DWA OPROGRAMOWANIA WIDEOSTROBOKIMOGRAFII OCENIAJĄCE WSPÓŁCZYNNIK OTWARCIA FAŁDÓW GŁOSOWYCH: OPINIA UŻYTKOWNIKA

Streszczenie

Wstęp: Laryngovideostroboskopia (LVS) jest złotym standardem wśród metod oceny krtani. Interpretacja badania jest wysoce zależna od kompetencji i doświadczenia osoby badającej. Możliwość obiektywizacji LVS, dotąd uznawanej za metodę subiektywną, daje narzędzie do dokładniejszej diagnostyki chorób krtani.

Cel: Celem pracy było porównanie oprogramowań do oceny wideostrobokimograficznej (VSK) : Divas i DiagnoScope. Ponadto porównano wyniki współczynników otwarcia (OQ) – parametrów wyliczanych za pomocą obu programów.

Materiał i Metoda: 23 nagrania LVS osób bez zaburzeń głosu zostało przeanalizowane za pomocą oprogramowań Divas (Xion Medical) i DiagnoScope Specialist (DiagNova Technologies).

Wyniki: Średnia wieku w analizowanej grupie wynosiła 41.1 lat. Wśród kobiet: 39.6, wśród mężczyzn: 42.4. Średnia wartość OQ_{VSK} uśrednionego z trzech części głośni mierzona przez Divas wynosiła 0.519 a przez DiagnoScope 0.517. Test t-Student nie pokazał statystycznych różnic pomiędzy uzyskanymi z obu metod parametrami. Wartość bezwzględna wszystkich pomiarów wynosiła do 0.18. U 50% pacjentów różnica pomiędzy metodami nie przekraczała 0.05 a u 87%, 0.1. Największe różnice dotyczyły parametrów mierzonych z przedniej części głośni.

Wnioski: Wartości OQ_{VSK} wyliczone przez różne oprogramowania do analizy kinemograficznej są porównywalne. Moduły do oceny wideostrobokimograficznej wymagają dopracowania w celu optymalizacji czasu potrzebnego na analizę.

Słowa kluczowe: laryngostroboskopia, kinematografia, fałdy głosowe

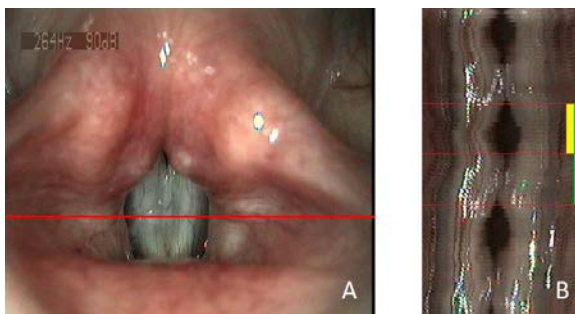


Figure 1. Sample images from Divas. **(A)** An LVS recording with the red line marking the middle third of the vocal folds. **(B)** Kymogram created from the selected line. The examiner marks the glottal cycle (green) and the ends of the open phase (yellow). The Open Quotient (OQ) value is then automatically calculated. In this case $OQ_{VSK} = 0.5$

Introduction

Laryngovideostroboscopy (LVS) is the gold standard among diagnostic tools for the larynx [1]. The interpretation of the examination is highly dependent on the examiner's competence and knowledge [2]. Adam Mickiewicz, a Polish poet of the Romantic era, wrote that "Feeling and faith speak more clearly to me, than the lenses and eye of the sage" [3], a statement which might apply to the subjective methods which otolaryngology and phoniatry presently rely on to diagnose the larynx.

First introduced in 1999 [4], videostrobokymography (VSK) is a method to objectively measure vibration of the vocal folds [5]. Kymograms extracted from LVS recordings can not only be assessed visually, but can also be analysed further using computer software [6]. With VSK, one can assess differences in the amplitude, phase, symmetry, and regularity of vocal fold vibration. In order to make the measurement objective, certain parameters have

Table 1. Comparison of the kymographic mode of DiagnoScope and Divas

Features	DiagnoScope	Divas
Videostrobokymography		
Menu/Console	All steps in kymography development and analysis are viewed in separate windows. To choose another part of a recording, one has to go back to the first window menu	On the console, 2 windows are always visible: one for scrolling the LVS recording, the other the created kymogram
Selection of video recording	The beginning and the end of the recording submitted for further analysis are chosen; the selected portion is then further processed	Only the starting point of the recording can be chosen for further analysis
Duration of kymograms	Depending on previously selected duration of video recording. The examiner chooses the number of cycles they want to analyse from the selected film	The examiner chooses the duration of VSK analysis: 2, 4, or 7 seconds
Glottal phase marking	Automatic The researcher chooses the number of cycles for further analysis	Manual The researcher marks each glottal cycle
OQ measurement	OQ results presented as a graph: x-axis represents OQ value and y-axis represents location on vocal fold	OQ result displayed when the cycle is selected
Time required for kymographic analysis	Over a dozen minutes	A few minutes
Additional options		
Image stabilization	Available	Not available. The LVS needs to be carefully recorded with a steady hand
Brightness deviation reduction	Available This option does not reduce problems caused by mucosal bridges in the upper parts of larynx; the program then has trouble distinguishing the glottis from vocal folds during thresholding	Not available The examiner is able to manually mark parts of the glottal cycle
Graphic vocal fold amplitude analysis: –value –symmetry –phase difference		

been proposed [7]. The Open Quotient (OQ) is the basic parameter available in VSK software, and is defined as the time the vocal folds are apart (opening, opened, and closing phases), divided by the time for the whole glottal cycle. The literature shows OQ is extremely useful in monitoring and diagnosing voice disorders [8,9].

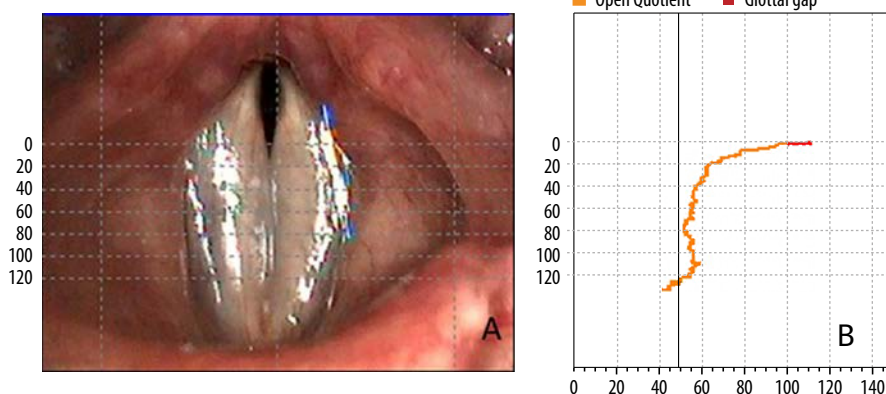
Aim

The aim of the study was to test two different types of VSK software. Another aim was to compare the Open Quotient values obtained using the two programs: Divas and DiagnoScope.

Material and Method

Exactly 23 LVS recordings from a group of euphonic people (non-smoking, non-professional voice users) were made. The recordings were then analyzed with Divas software (Xion Medical EndoSTROB-DX 327 system; Xion GmbH Berlin, Germany) and DiagnoScope Specialist software (DiagNova Technologies, Wrocław, Poland). 11 women and 12 men underwent LVS with a rigid endoscope. Recordings were made during comfortable, prolonged phonation of [e]. The study design was approved by the Bioethics Committee at the Institute of Physiology and Pathology of Hearing in Warsaw (IFPS: KB/07/2013).

Figure 2. Images from DiagnoScope. (A) An LVS recording with horizontal lines marked at various intervals across the glottis. (B) The corresponding OQ_{VSK} graph in which the horizontal axis is the OQ_{VSK} value; the vertical axis is position along the glottis



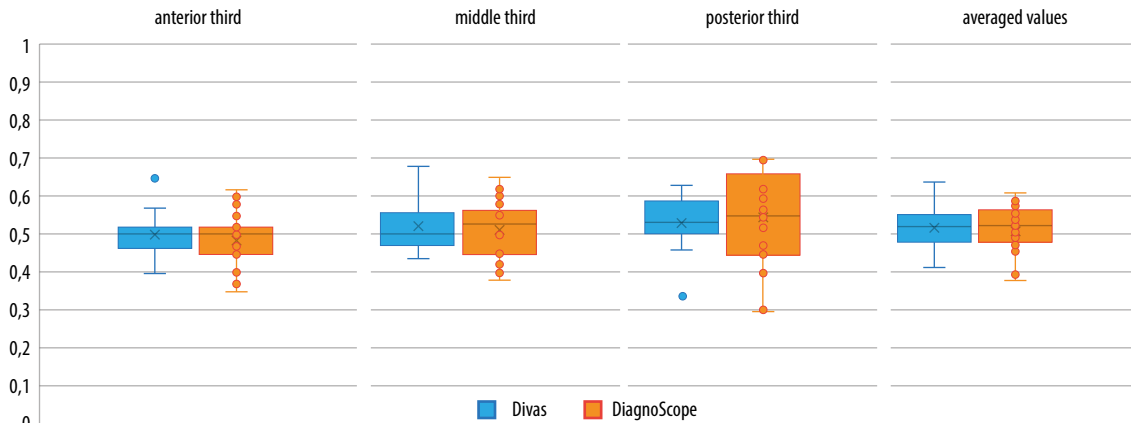


Figure 3. Comparison of average OQ_{VSK} values for Divas (blue) and DiagnoScope (orange). Box plots show medians, standard deviations, extreme values, and outliers at three different places along the glottis

A comparison of the kymographic mode of the two types of software is shown in Table 1. In both, OQ_{VSK} was measured from the middle of the anterior, middle, and posterior part of the membranous parts of the vocal fold [10,11]. In the Divas software, the researcher manually selected a place on the glottis from which OQ_{VSK} was calculated [8]. Figure 1 presents an example of VSK created in Divas. In comparison, DiagnoScope software presents the results of OQ_{VSK} as a graph, where the x-axis represents the OQ_{VSK} value and the y-axis represents the location on the vocal fold. Figure 2 is an example of VSK created in DiagnoScope. In the software, parameters are measured at more than 100 points along the glottis (each pixel on the graph represents a separate measurement point, which will depend on the resolution of source video material and the applied zoom). In DiagnoScope, we took OQ_{VSK} to be the local mean value ± 5 units around the mid-point of the anterior glottal third.

Results

The mean age in the study group was 41.1 (SD 12.6); in women it was 39.6 (SD 13.4) and in men 42.4 (SD 10.8). Two patients were excluded from further analysis (1 man and 1 woman) because of mucosal bridges in the upper part of the larynx or uvula during LVS recording which caused brightness fluctuations that prevented calculation of values in DiagnoScope. The mean OQ_{VSK} value averaged from all three parts of the glottis measured by Divas was 0.519 (SD 0.065) and by DiagnoScope, 0.517 (SD 0.096). A two-sided paired Student t-test showed no significant differences between the parameters. Figure 3 demonstrates box plots of OQ_{VSK} values measured with the two types of software.

The absolute differences of all measurements were less than 0.18. In 50% of patients, the differences in measurements did not exceed 0.05 and in 87%, 0.1. The largest differences in measurements were observed in the anterior part of the vocal folds. The Bland–Altman method was used to compare results obtained in repeated measurements (plotted in Figure 4). The calculated mean difference was 0.0038 and, based on a t-test, it was not significantly different to 0 ($p = 0.67$). Figure 4 shows that differences

were concentrated around 0, without any visible trends – either for the aggregated sample or for all parts of the vocal folds analysed separately. There were only two observations outside the 95% confidence interval.

Discussion

Software presently available on the market with a laryngovideostrobokymographic module requires additional fine-tuning to restrict the recording analysis time as much as possible. The study compares Divas software made by Xion and DiagnoScope Specialist made by DiagNova. In their present form, both tools need modification in order to facilitate and accelerate the laryngovideostrobokymographic parametrization process. In the author's opinion the main criticism of the Xion software is the lack of image stabilization and the need to manually mark the individual phases of the glottic cycle. Because of this, kymographic analysis takes from 5 to 10 minutes. Analysis using the DiagnoScope Specialist software in the advanced kymography module takes twice as long. Sampling of folds from multiple test locations gives detailed information on mucosal waveform characteristics, but in daily clinical practice it would be more useful to present the results averaged over just 3 glottal locations. Currently, it is not possible to simply transform the graphically generated OQ_{VSK} results. Developers of DiagnoScope, however, assure us that in the near future this feature will be available in the kymographic analysis module. On the other hand, the basic kymography module is very easy to use; when a researcher selects part of the recording, the module automatically generates kymograms upon image stabilization. Supplemented with opening parameters, the module could form the basis for development of an efficient, objective laryngovideostroboscopic instrument. The authors believe that the researcher should be able to manually mark the glottis area for further analysis. The software could then divide the marked area into 3 equal parts and deliver averaged OQ_{VSK} results. Analysis of recordings in such a format would greatly facilitate and accelerate kymographic analysis.

The above comments on how mucosal wave opening coefficients measurements could be improved are intended

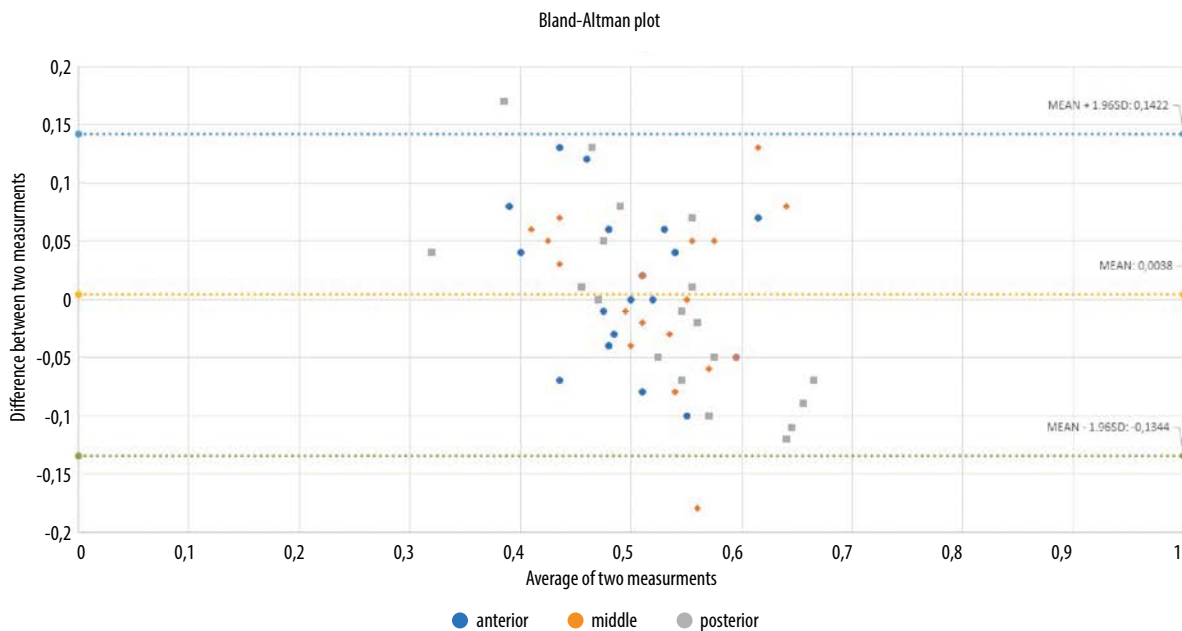


Figure 4. A Bland–Altman plot showing differences between repeated measurements made with the Divas and DiagnoScope software. The differences are concentrated around 0, with no visible trends

to guide the usefulness of clinical equipment. Reducing the time needed to make objective measures of direct and indirect laryngeal parameters would make the tool more useful in everyday clinical practice.

Conclusions

The trend in modern medicine is towards automatic measurement techniques using dedicated software. New

technology opens up the possibility of gaining objective LVS data through OQ_{VSK} . Objective LVS data opens up a way of precisely diagnosing laryngeal diseases, which currently relies on subjective methods. The average OQ_{VSK} values are comparable when either of the two types of measurement software are used. However, software currently available on the market with a laryngovideostroboscopic module requires fine-tuning to limit the analysis time as much as possible.

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