

UNIVERSIDADE FEDERAL DE MINAS GERAIS

Faculdade de Medicina

**VIDEOLARINGOSCOPIA DE ALTA VELOCIDADE: CARACTERÍSTICAS
LARÍNGEAS E DE FECHAMENTO GLÓTICO EM MULHERES E HOMENS**

Ualisson Nogueira do Nascimento

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Trabalho apresentado à banca de defesa de
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VIDEOLARINGOSCOPIA DE ALTA VELOCIDADE: CARACTERÍSTICAS LARÍNGEAS E DE FECHAMENTO GLÓTICO EM MULHERES E HOMENS

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Resumo da Dissertação / Descritores

Introdução

A videolaringoscopia de alta velocidade (HSV) e as análises de processamento de imagens derivadas dela, a forma da onda da área glótica (GAW) e a videoquimografia digital (DKG), se tornaram ferramentas relevantes na precisão diagnóstica e terapêutica de padrões irregulares do ciclo glótico das pregas vocais, comum nas alterações laringeas. A alta taxa de captura da HSV e a possibilidade de análise dos parâmetros derivados das imagens laringeas geradas, podem fornecer relevantes achados na investigação das alterações do fechamento glótico.

Objetivo

Investigar as características vibratórias das pregas vocais com alteração de fechamento glótico com a HSV e analisar os parâmetros da GAW e da DKG de mulheres e homens.

Métodos

Estudo observacional transversal aprovado pelo Comitê de Ética em Pesquisa (COEP-UFMG) da Universidade Federal de Minas Gerais (UFMG), sob os números CAAE 44848115.0.0000.5149 e 59014916.6.0000.5149. A amostra foi formada a partir de um banco de imagens laringeas da HSV do Observatório de Saúde Funcional em Fonoaudiologia da Universidade Federal de Minas Gerais (OSF/UFMG). Os sujeitos do banco de dados passaram por avaliação fonoaudiológica e otorrinolaringológica na qual os pacientes sem alteração do fechamento glótico apresentaram qualidade vocal neutra e não possuíam queixa vocal e os indivíduos selecionados com alterações do fechamento glótico tinham queixa vocal e/ou alteração na qualidade da voz. Foram selecionados 65 sujeitos para análise dos dados, e foram alocados em quatro grupos: 20 mulheres com fechamento glótico completo (idade média: 28,8 anos; entre 18 e 45 anos), 20 mulheres com alteração de fechamento glótico (idade média: 24,95 anos, entre 18 e 35 anos), 20 homens com fechamento glótico completo (idade média: 26,85 anos; entre 19 e 44 anos) e cinco homens com alteração de fechamento glótico (idade média: 25,4 anos; entre 21 e 35 anos). Os grupos com fechamento glótico completo e com alteração de fechamento glótico foram pareados por idade, sem diferenças entre os grupos de mulheres (p -valor=0,11) e de homens (p -valor=0,92). Das imagens laringeas da HSV, foram extraídos e analisados os parâmetros da GAW e da DKG pelo programa KIPS® da KayPENTAX®. O teste de Anderson-Darling foi utilizado para verificar a normalidade da amostra e o teste Mann-Whitney para comparação dos parâmetros da GAW da DKG entre os grupos.

Resultados

Dos indivíduos com fenda glótica houveram 11 mulheres com fenda posterior (55%), seis com fenda em ampulheta (30%), e três com fenda anterior (15%); quatro homens (80%) com fenda posterior e um (20%), fenda anterior. Observou-se significância estatística entre resultados da GAW para maior área mínima e menor taxa de mudança de área máxima nas mulheres e nos homens e menor área máxima, maior taxa de mudança de área mínima e maior quociente de velocidade nos homens. Os parâmetros da DKG indicaram, menor abertura máxima e média nas regiões média e anterior das pregas vocais das mulheres e homens. Menor

abertura máxima nas regiões posterior e média, menor amplitude de abertura da prega vocal esquerda na região posterior, maior frequência da variação de abertura das pregas vocais direita e esquerda na região anterior e da prega vocal direita na região posterior. A porcentagem de fase fechada foi menor na região posterior para os homens e mulheres e maior nas regiões anterior e média nas mulheres.

Conclusão

Os achados apresentaram maior impacto dos parâmetros da GAW e da DKG nos homens com alteração do fechamento glótico. A região posterior da glote indicou maior alteração nos homens e as regiões média e anterior nas mulheres. Observou-se que principalmente, a área mínima, a amplitude e a frequência de abertura das pregas vocais possibilitam caracterizar as alterações do fechamento glótico nos grupos de mulheres e homens.

Descritores: laringoscopia, quimografia, glote, prega vocal, distúrbio da voz

Abstract / Keywords

Introduction

High-speed videoendoscopy (HSV) and derived image processing, the glottal area waveform (GAW) and digital videoquimography (DKG), have become relevant tools in the diagnostic and therapeutic accuracy of irregular cycle patterns of the vocal folds, common in laryngeal alterations. The high rate of HSV capture and the possibility of analyzing the parameters derived from the generated laryngeal images may provide relevant findings in the investigation of changes in glottal closure.

Objective

To investigate the vocal fold vibratory characteristics in altered glottal closure with HSV and to analyze GAW and DKG parameters in women and men.

Methods

Cross-sectional observational study approved by the Research Ethics Committee of UFMG-COEP, under the numbers CAAE 44848115.0.0000.5149 and 59014916.6.0000.5149. The sample was formed from a laryngeal image of the HSV of the Functional Health Observatory in Speech Therapy (OSF / UFMG). The subjects in the database underwent an otorhinolaryngological and a voice evaluation in which the patients without alteration of the glottal closure presented neutral vocal quality and had in the vocal complaint and the individuals selected with alterations of the glottal closure had vocal complaint and / or alteration in the quality of voice. Sixty-five subjects were selected for analysis of the data, and 20 were women with complete glottal closure (mean age: 28.8, 18-45), 20 women with glottal chink (mean age: 24.95, 18-35) 20 men with complete glottal closure (mean age: 26.85, 19-44), and five men with glottal chink (mean age: 25.4, 21-35).

The groups with complete glottal closure and with glottal chink were paired by age, with no differences between the groups of women (p -value = 0.11) and men (p -value = 0.92). The GAW and DKG parameters were extracted from the laryngeal images of HSV analyzed by the image processing program KIPS® of KayPENTAX®. The Anderson-Darling test was used to verify normality of the sample and the Mann-Whitney test for comparison of GAW parameters of DKG between groups.

Results

Among the individuals with glottal chink, 11 women with posterior gap (55%), six with hourglass (30%), and three, anterior glottal gap (15%); four men (80%) with posterior gap and one (20%), anterior glottal gap. Statistical significance was observed between GAW results for a greater minimum area and maximum area rate of change in women and men. A lower maximum area, higher minimum area rate of change, and higher speed quotient in men. The DKG parameters indicated a lower maximal and mean opening in the middle and anterior regions of the vocal folds of women and men. Lower maximal opening in the posterior and middle regions, lower dominant amplitude of the opening variation of the left vocal fold in the posterior region, greater dominant frequency of the opening variation of the left vocal fold in the anterior region and of the right vocal fold in the posterior region in men. The percentage of close was lower in the posterior region for men and women and higher in the anterior and middle regions in women.

Conclusion

The findings had a greater impact of GAW and DKG parameters in men with glottal chink. The posterior region of the glottis indicated greater alteration in men, and in the middle and anterior in women. It was observed that, mainly, the minimal area, the amplitude and the frequency of opening of the vocal folds allow characterizing the alterations of the glottal closure in the groups of women and men.

Keywords: laryngoscopy, kymography, glottis, vocal fold, voice disorder.

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CONSIDERAÇÕES INICIAIS

A avaliação das imagens da laringe é importante ferramenta na análise, subjetiva e objetiva, do padrão de vibração das pregas vocais (PPVV) ¹. A videoestroboscopia se tornou, dentre os instrumentos clínicos de visualização laríngea, essencial na avaliação otorrinolaringológica, na qual permite a observação em tempo real dos mecanismos da fonação ².

No começo do século 19, observava-se que através da sucessão rápida de imagens, a percepção visual de movimento poderia ser provocada. Oertel ³, no final do mesmo século, utilizou os princípios da estroboscopia para aplicar na visualização da movimentação das PPVV. Em seu experimento, a luz estroboscópica ao incidir sobre o espelho laríngeo para iluminar as PPVV, refletia uma sequência de imagens percebidas pelo examinador como um movimento lento, representativo do padrão vibratório das PPVV ².

O sistema da videoestroboscopia, formado por um estroboscópio e uma câmera, captura o movimento das PPVV a uma taxa entre 24 a 30 imagens por segundo ¹. Ao incidir sobre a glote, a luz estroboscópica provoca um movimento ilusório de câmera lenta da vibração das PPVV, dessa forma, não se visualiza o movimento real das PPVV (o ciclo glótico vibratório é composto por imagens de diferentes ciclos), o que torna a videoestroboscopia aplicável para vibrações periódicas, mas frequentemente impossibilita a visualização de vibrações assimétricas ^{1,4}.

Na década de 30, foi criada uma tecnologia de fotografias de alta velocidade, chamada *ultra-high-speed motion picture camera* e, posteriormente, no começo dos anos 40, com o uso da tecnologia digital, possibilitou-se a gravação em vídeo de alta

velocidade do movimento das PPVV com a *high-speed video* ⁵. Ambas tecnologias apresentavam imagens em preto e branco, baixa resolução e alto custo, tornando-as impraticáveis como instrumentos clínicos. Diferentemente da videoestroboscopia, que desde a década de 60, tornou-se o método mais utilizado para a análise da vibração das PPVV ⁶.

Em 2003, com computadores com maior capacidade de armazenamento e processamento dos dados, surgiu a *high-speed videoendoscopy* (HSV). Colorida, com maior resolução e qualidade, possibilitou a captura do movimento das PPVV a uma taxa em torno de 2000 a 4000 imagens por segundo, tornou possível novamente a captura do movimento das PPVV em alta velocidade com aplicação clínica ⁷⁻⁹.

A HSV registra, em detalhes, o ciclo completo das PPVV, e permite investigar o comportamento dinâmico delas. A partir deste registro, é possível a análise quantitativa das imagens laríngeas via *software* ¹. A região das PPVV é identificada, o algoritmo do programa de análise gera o cálculo da área glotal e processa cada imagem do vídeo para construir os sucessivos ciclos glóticos. Essa série temporal, que representa a variação real da área glotal e os movimentos de vibração das PPVV, recebe o nome de forma da onda da área glótica ou *glottal area waveform* (GAW) ¹⁰.

Uma outra análise derivada da HSV é a videoquimografia digital ou *digital kymography* (DKG). Na videoquimografia convencional, criada nos anos 90 como um método de vídeo-documentação complementar à estroboscopia, cada imagem da área glótica é composta por linhas horizontais, na qual há a seleção de uma linha de cada vez para observar as imagens do ciclo vibratório através do tempo ¹¹. A DKG supera as limitações da videoquimografia convencional com a possibilidade de

analisar, em uma mesma amostra de ciclo glótico, toda a extensão da borda livre das PPVV, na seleção de múltiplas linhas ou trechos para análise ^{12,13}.

Como instrumento de registro do movimento real das PPVV, a HSV permite analisá-las e caracterizá-las em diferentes condições vocais, como em padrões vibratórios aperiódicos, típico de vozes disfônicas ^{10,12,14}.

Figura 1. Comparação das características entre estroboscopia e videolaringoscopia de alta velocidade (HSV).

Características	Estroboscopia	HSV
Número de imagens captadas	24-30fps	2000-4000fps
Registro das imagens captadas	Movimento ilusório de câmera lenta	Movimento em câmera lenta
Registro do ciclo das PPVV	Composição de imagens de diferentes ciclos vibratórios	Registro real do ciclo completo
Caracterização dos padrões vibratórios	Aplicado a vibrações periódicas	Possibilita visualização de vibrações assimétricas
Tamanho dos arquivos	Baixo armazenamento	Exige armazenamento alto

O fechamento glótico é definido pelas configurações das PPVV (forma da glote) durante o fechamento máximo do ciclo vibratório ¹⁵. Quando a glote não está completamente fechada, indicativo de padrões vibratórios aperiódicos das PPVV, apresenta uma região com coaptação glótica ineficiente, associado a diferentes fatores etiológicos (inadaptações miodinâmicas da laringe, presença de lesões orgânicas, variabilidade de tamanho e de configuração das PPVV) ^{15,16}.

Há sete formas mais comuns de fechamento glótico: fechamento completo, fenda glótica anterior, fenda irregular, fenda fusiforme central, fenda em ampulheta, fenda posterior e fechamento incompleto ¹⁷.

Fechamento completo indica total coaptação glótica das PPVV; fenda glótica anterior, normalmente apresenta uma forma de fuso na região anterior da glote ^{17,18}; fenda irregular, comumente causada por lesões de massas e o fechamento é desigual na extensão das PPVV ¹⁸; fenda fusiforme central, apresenta como característica a presença de um fuso na região anterior das PPVV ^{17,18}; fendas em ampulheta, indicam coaptação ineficiente em duas regiões, decorrentes, em geral, de lesão de mucosa no terço anterior e médio das PPVV ¹⁸; fenda posterior, se manifesta, normalmente no formato de um triângulo na região posterior da glote e pode relacionar-se com aproximação incompleta dos processos vocais ¹⁷; e o fechamento incompleto, caracterizado por uma fenda em toda a extensão das PPVV ¹⁷.

Com o avanço tecnológico das imagens laríngeas, hoje é possível individualizar os ciclos glóticos e comparar os momentos de fase aberta e fechada, assim como é possível analisar a diferença vertical da borda livre das PPVV ¹⁹. Ainda há poucos estudos na literatura que utilizaram a GAW e a DKG. Esta pesquisa pretende de maneira objetiva, compreender o comportamento dinâmico das PPVV, e avaliar o fechamento glótico por meio da HSV, para, com esse método avaliativo, investigar os padrões vibratórios aperiódicos e a importância dessa ferramenta na indicação terapêutica e diagnóstica nessas configurações das PPVV.

O presente estudo foi aprovado pelo Comitê de Ética em Pesquisa (COEPUFMG) da Universidade Federal de Minas Gerais, sob os números CAAE 44848115.0.0000.5149 e 59014916.6.0000.5149 (Anexo 1). Todos os participantes

foram informados quanto aos objetivos e procedimentos da pesquisa e assinaram, mediante leitura prévia e esclarecimento de dúvidas, o termo de consentimento livre e esclarecido (TCLE).

Os resultados encontrados neste projeto de pesquisa, de acordo com a Resolução nº 01/2015 de março de 2015 (Anexo 2), do programa de pós-graduação em Ciência Fonoaudiológicas da Universidade Federal de Minas Gerais, serão apresentados em formato de artigo científico, intitulado: "*Incomplete glottal closure in adults within high-speed videoendoscopy analysis*", que será submetido ao periódico *Journal of Voice*, estruturado de acordo com as normas do periódico (Anexo 3).

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OBJETIVOS

Objetivo geral

Analisar as características do ciclo vibratório das PPVV de mulheres e homens com alteração de fechamento glótico, por meio da videolaringoscopia de alta velocidade.

Objetivos específicos

- Investigar os parâmetros da forma da onda da área glótica de mulheres e homens com alteração de fechamento glótico e compará-los com mulheres e homens com fechamento glótico completo.

- Estudar as características de amplitude e simetria do ciclo vibratório das pregas vocais de mulheres e homens com alteração de fechamento glótico e compará-los com mulheres e homens com fechamento glótico completo.

- Compreender as possibilidades clínicas e de diagnóstico dos parâmetros quantitativos de análise do movimento vibratório das PPVV em situações de fechamento glótico incompleto.

RESULTADOS E DISCUSSÃO

Os resultados dessa dissertação serão apresentados no formato de artigo, intitulado: “*Incomplete glottal closure in adults within high-speed videoendoscopy analysis*”, que será submetido ao periódico *Journal of Voice*.

CONSIDERAÇÕES FINAIS

Diante do avanço tecnológico e das novas possibilidades clínicas, a videolaringoscopia de alta velocidade encaminha para se consolidar como uma nova ferramenta de diagnóstico das alterações laríngeas em âmbito clínico. Como ferramenta de avaliação laríngea, que permite a gravação imagem por imagem do comportamento dinâmico das pregas vocais, a HSV se tornou imprescindível para diagnóstico diferenciado do movimento aperiódico presente nas alterações laríngeas.

A proposta do presente estudo foi investigar as possibilidades da avaliação quantitativa dos exames de imagem laríngeos por meio da HSV e permitir melhor compreensão para otorrinolaringologistas e fonoaudiólogos sobre a dinâmica do ciclo vibratório das pregas vocais com alterações de fechamento glótico.

As análises quantitativas derivadas dos exames laríngeos gravados por meio da HSV, a forma da onda da área glótica e a videoquimografia digital, permitiram corroborar com os resultados da avaliação visual dos exames de imagem sobre PPVV com alterações de fechamento glótico, com a confirmação objetiva das implicações das fendas glóticas nas fases fechada, de fechamento e abertura do ciclo glótico e na amplitude de movimento das PPVV. Os resultados possibilitaram também, complementar a compreensão clínica da movimentação vertical da mucosa com dados objetivos, que apenas em uma inspeção visual das PPVV não seria viável.

A HSV se mostra ferramenta promissora para auxiliar no diagnóstico, prevenção e conduta terapêutica de alterações laríngeas. Entretanto o seu alto custo e a falta de padronização dos resultados possibilitados pelo exame retardam um

avanço científico mais sólido na compreensão do significado clínico dos parâmetros investigados.

ANEXOS

Anexo 1



UNIVERSIDADE FEDERAL DE MINAS GERAIS
COMITÊ DE ÉTICA EM PESQUISA - COEP

Projeto: CAAE – 44848115.0.0000.5149

Interessado(a): Profa. Ana Cristina Côrtes Gama
Departamento de Fonoaudiologia
Faculdade de Medicina- UFMG

DECISÃO

O Comitê de Ética em Pesquisa da UFMG – COEP aprovou, no dia 26 de junho de 2015, o projeto de pesquisa intitulado "**Avaliação anatomofuncional das lesões benignas da laringe através da videolaringoscopia digital de alta velocidade**" bem como o Termo de Consentimento Livre e Esclarecido.

O relatório final ou parcial deverá ser encaminhado ao COEP um ano após o início do projeto através da Plataforma Brasil.

A handwritten signature in blue ink, reading 'Telma Campos Medeiros Lorentz', is written over the printed name.

Profa. Dra. Telma Campos Medeiros Lorentz
Coordenadora do COEP-UFMG



UNIVERSIDADE FEDERAL DE MINAS GERAIS
COMITÊ DE ÉTICA EM PESQUISA - COEP

Projeto: CAAE – 59014916.6.0000.5149

Interessado(a): **Profa. Ana Cristina Côrtes Gama**
Departamento de Fonoaudiologia
Faculdade de Medicina- UFMG

DECISÃO

O Comitê de Ética em Pesquisa da UFMG – COEP aprovou, no dia 31 de agosto de 2016, o projeto de pesquisa intitulado “**Efeitos da eletroestimulação associada ao programa integral de reabilitação vocal em cantoras com queixas cervicais e vocais**” bem como o Termo de Consentimento Livre e Esclarecido.

O relatório final ou parcial deverá ser encaminhado ao COEP um ano após o início do projeto através da Plataforma Brasil.

Prof.^a Dr.^a Vivian Resende
Coordenadora do COEP-UFMG

Anexo 2



FACULDADE DE MEDICINA
CENTRO DE PÓS-GRADUAÇÃO

Av. Prof. Alfredo Balena 190/ sala 533
Belo Horizonte – MG - CEP 30.130-100
Fone: (031) 3409.9641/ 3248.9640
E-mail: cpg@medicina.ufmg.br



Curso de Pós-Graduação em Ciências Fonoaudiológicas

Resolução nº01/2015, de 26 de março de 2015.

Regulamenta o formato de dissertações do Curso de Pós-Graduação em Ciências Fonoaudiológicas da Faculdade de Medicina da UFMG

O Colegiado do Programa de Pós-Graduação em Ciências Fonoaudiológicas, no uso de suas atribuições, e considerando a necessidade de regulamentar o formato das dissertações do Programa.

RESOLVE:

Art. 1º A dissertação de mestrado poderá ser elaborada no formato convencional e no formato de artigo.

Parágrafo único - O formato de artigo é considerado preferencial pelo colegiado do Programa.

Art. 2º O Colegiado do Curso de Pós-Graduação em Ciências Fonoaudiológicas propõe o seguinte roteiro para elaboração da dissertação no formato de artigo:

1. Capa
2. Folha de Rosto
3. Folha da Instituição
4. Declaração de Defesa
5. Resumo da dissertação/Descritores (1300 palavras/3 a 5 descritores)
6. Abstract/Keywords
7. Sumário
8. Introdução ou considerações iniciais: duas a três paginas com breve fundamentação teórica e/ou contextualização do tema cujos resultados serão apresentados sob formato de artigo ou artigos;
9. Objetivos: redigido da forma convencional (uma ou duas páginas);
10. Métodos: redigido da forma convencional e detalhado (se necessário);
11. Resultados e discussão: sob a forma de artigo ou artigos;
12. Conclusão ou considerações finais: até cinco paginas.
13. Anexos/Apêndices

Art. 3º O Colegiado do Curso de Pós-Graduação em Ciências Fonoaudiológicas propõe o seguinte roteiro para elaboração da dissertação no formato convencional:

1. Capa



2. Folha de Rosto
3. Folha da Instituição
4. Declaração de Defesa
5. Resumo da dissertação/Descritores (1300 palavras/3 a 5 descritores)
6. Abstract/Keywords
7. Sumário
8. Introdução;
9. Revisão da literatura;
10. Objetivos;
11. Métodos;
12. Resultados;
13. Discussão;
14. Conclusão;
15. Referências bibliográficas;
16. Anexos/Apêndices.

Art. 4º - Outros aspectos de formatação:

1. Referências bibliográficas: serão apresentadas após cada sessão da dissertação de acordo com as normas de Vancouver e conforme as recomendações específicas de cada periódico para os quais os artigos serão submetidos. 2. A dissertação de mestrado poderá conter os textos escritos na língua inglesa, de acordo com esta resolução.

Art. 5º. Os casos omissos e especiais serão decididos pelo Colegiado de Pós-Graduação.

Art. 6º. Esta Resolução entra em vigor na data de sua aprovação.

Ficam revogadas todas as disposições em contrário, em especial a Resolução 01/2014.

Resolução aprovada pelo Colegiado do Curso de Mestrado em
Ciências Fonoaudiológicas em 26/03/2015.

Resolução aprovada pela Câmara de Pós-Graduação em 28/04/2015

Profa. Ana Cristina Côrtes Gama
Coordenadora do Curso de Pós-Graduação em Ciências Fonoaudiológicas

Anexo 3

Submission checklist

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Reference to a book:

[3] W. Strunk Jr., E.B. White, The Elements of Style, fourth ed., Longman, New York, 2000.

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[4] G.R. Mettam, L.B. Adams, How to prepare an electronic version of your article, in: B.S. Jones, R.Z. Smith (Eds.), *Introduction to the Electronic Age*, E-Publishing Inc., New York, 2009, pp. 281–304.

Reference to a website:

[5] Cancer Research UK, Cancer statistics reports for the UK.

<http://www.cancerresearchuk.org/aboutcancer/statistics/cancerstatsreport/>, 2003 (accessed 13 March 2003).

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[dataset] [6] M. Oguro, S. Imahiro, S. Saito, T. Nakashizuka, Mortality data for Japanese oak wilt disease and surrounding forest compositions, Mendeley Data, v1, 2015. <https://doi.org/10.17632/xwj98nb39r.1>.

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