UNIVERSIDADE ESTADUAL DE CAMPINAS
FACULDADE DE ODONTOLOGIA DE PIRACICABA

ANA PAULA GADONSKI

FUNÇÃO SENSORIAL ORAL EM INDIVÍDUOS COM ALTERAÇÃO DE NORMALIDADE DA LÍNGUA

ORAL SENSORY FUNCTION ON SUBJECTS WITH TONGUE LESIONS

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Dissertação apresentada à Faculdade de Odontologia de Piracicaba da Universidade Estadual de Campinas como parte dos requisitos exigidos para a obtenção do título de Mestra em Clínica Odontológica, Área de Prótese Dental.

Dissertation presented to the Piracicaba Dental School of the University of Campinas in partial fulfillment of the requirements for the degree of Master in Clinical Dentistry, in the Prosthodontics area.

Orientadora: Profa. Dra. Renata Cunha Matheus Rodrigues Garcia

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- ORCID do autor: https://orcid.org/0000-0001-7420-9833
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PROFª. DRª. RENATA CUNHA MATHEUS RODRIGUES GARCIA

PROFª. DRª. DANIELA MICHELINE DOS SANTOS

PROF. DR. WANDER JOSÉ DA SILVA

A Ata da defesa, assinada pelos membros da Comissão Examinadora, consta no SIGA/Sistema de Fluxo de Dissertação/Tese e na Secretaria do Programa da Unidade.

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RESUMO

A estereognose oral (EO) assume importante papel na reabilitação oral de pacientes parcial e/ou totalmente desdentados, pois influencia a adaptação dos mesmos às novas próteses. Devido à característica essencialmente tátil da percepção sensorial oral, a língua parece desempenhar importante função sobre a EO. Entretanto, existem controvérsias em relação ao papel do palato, e pouco se sabe sobre a influência das alterações da superfície da língua sobre a EO e função gustativa. Desta forma, este trabalho teve por objetivo *(1)* revisar sistematicamente a influência do recobrimento palatino, por meio de próteses ou dispositivos palatinos, sobre a EO (Artigo 1); e *(2)* avaliar por meio de estudo clínico a influência das alterações de normalidade de língua e recobrimento palatino sobre a EO e função gustativa de indivíduos dentados (Artigo 2). A revisão sistemática foi conduzida por meio de buscas nas bases de dados MEDLINE via PubMed, Scopus, Web of Sciences, Embase, Cochrane Library, e LILACS (Latin American and Caribbean Health Sciences Literature database) via Virtual Health Library, e literatura cinzenta via Google Scholar e Open Grey, nas quais a estratégia PICO foi utilizada para a formulação da pergunta foco, sendo P = pacientes dentados ou desdentados; I = recobrimento palatino por meio de próteses totais ou dispositivos palatinos; C = indivíduos sem nenhum tipo de recobrimento palatino; e O = EO. Para o estudo clínico foram selecionados 70 voluntários dentados (média de 30,71 ± 6,7 anos de idade), que foram divididos em 2 grupos: *(1)* voluntários diagnosticados com glossite migratória benigna, língua fissurada e/ou pilosa (experimental, n = 35), e *(2)* voluntários sem qualquer alteração de superfície da língua (controle, n = 35). Logo após a seleção, os indivíduos foram avaliados quanto à EO e função gustativa. O teste de EO envolveu a identificação intraoral de 6 formas geométricas confeccionadas em cenoura crua e agrupadas de acordo com a sua similaridade: *(1)* quadrado e retângulo; *(2)* círculo e elipse; e *(3)* triângulo e semicírculo. O tempo de resposta ao teste de EO, em segundos, foi registrado. A função gustativa foi avaliada por meio de soluções saborizadas (doce, salgado, azedo e amargo). Em seguida, dispositivos palatinos com recobrimento total do palato foram instalados em todos os voluntários, sendo a EO e função gustativa imediatamente reavaliadas. Os dados relativos às alterações de normalidade de língua foram submetidos ao teste Mann-Whitney, e aqueles relativos ao recobrimento palatino foram analisados por teste Wilcoxon. Na revisão sistemática não foram observadas diferenças na EO imediatamente após a instalação de próteses e dispositivos palatinos. Entretanto, a média de EO aumentou um mês ou mais após a instalação de próteses quando comparado às avaliações iniciais. No estudo clínico, não se observou diferença na EO e função gustativa entre os grupos experimental e controle, com ou sem recobrimento palatino ($p>0,05$). Entretanto, após o recobrimento palatino os indivíduos com alterações de normalidade de língua apresentaram maior tempo para realizar a identificação das formas

(p<0,05). Concluiu-se que a EO não é afetada pelo recobrimento palatino e melhora após a adaptação dos pacientes às próteses. As alterações de normalidade de língua ou recobrimento palatino não influenciam a EO e função gustativa. O tempo de resposta ao teste de EO foi maior em indivíduos com alteração de normalidade de língua após o recobrimento palatino.

Palavras-chave: Estereognose oral; Glossite migratória benigna; Língua fissurada; Língua pilosa; Alterações de normalidade de língua; Palato.

ABSTRACT

Oral stereognosis (OS) plays an important role in the oral rehabilitation of partially and/or edentulous patients, as it influences their adaptation to new prostheses. Due to the essentially tactile characteristic of oral sensory perception, the tongue seems to play an important role in OS. However, there are controversies regarding the role of the palate, and little is known about the influence of tongue lesions on OS and gustatory function. Thus, this study aimed to *(1)* systematically review the influence of palatal coverage, through prostheses or palatal devices, on OS (Article 1); and *(2)* to evaluate, through a clinical study, the influence of tongue lesions and palatal coverage on the OS and gustatory function of dentate individuals (Article 2). The systematic review was conducted by searching the literatures bases MEDLINE via PubMed, Scopus, Web of Sciences, Embase, Cochrane Library, and LILACS (Latin American and Caribbean Health Sciences Literature database) via Virtual Health Library, and gray literature via Google Scholar and Open Grey, in which the PICO strategy was used to formulate the focus question, with P = dentate or edentulous patients; I = palatal coverage by means of complete dentures or palatal devices; C = individuals without any type of palatalal coverage; and O = OS. For the clinical study, 70 dentate volunteers (mean age 30.71 ± 6.7 years) were selected and divided into 2 groups: *(1)* volunteers with benign migratory glossitis, fissured and/or hairy tongue (experimental, n = 35), and *(2)* volunteers without any alteration of the surface of the tongue (control, n = 35). Soon after selection, subjects were evaluated for OS and gustatory function. The OS test involved the intraoral identification of 6 geometric shapes made from raw carrots and grouped according to their similarity: *(1)* square and rectangle; *(2)* circle and ellipse; and *(3)* triangle and semi-circle. The response time to the OS test, in seconds, was recorded. The gustatory function was evaluated through the use of flavored solutions (sweet, salty, sour and bitter). After, palatal devices with full coverage of the palate were installed in all volunteers, being the OS and gustatory function immediately reassessed. Data related to tongue lesions were submitted to the Mann-Whitney test, and those related to palatal coverage were analyzed using the Wilcoxon test. In the systematic review, no differences were observed in OS immediately after the installation of prostheses and palatal devices. However, the OS mean increased one month or more after denture placement when compared to baseline assessments. In the clinical study, there was no difference in OS and gustatory function between the experimental and control groups, with or without palatal coverage ($p>0.05$). However, after palatal coverage, individuals with tongue lesions presented more time to identify shapes ($p<0.05$). It was concluded that OS is not affected by palatal coverage and improves after patients adaption to dentures. Tongue lesions or palatal coverage do not influence the OS and gustatory function. The response time to the OS test was longer in individuals with tongue lesions after palatal coverage.

Key-words: Oral stereognosis; Benign migratory glossitis; Fissured tongue; Hairy tongue; Tongue lesions; Palate.

SUMÁRIO

1 INTRODUÇÃO

A estereognose oral (EO) consiste na habilidade de reconhecer características como tamanho, textura e forma de diferentes objetos durante a mastigação, usando apenas a percepção sensorial oral (Fukutake *et al*., 2019), sem influência visual ou auditiva (Dalaya, 2014). Esta experiência sensitiva é decorrente de receptores presentes nos tecidos bucais, e sua funcionalidade e intensidade de resposta depende da sua distribuição intraoral (Steele *et al*., 2014; Snyder & Bartoshuk, 2016). Em sua maior parte, os receptores sensoriais encontram-se na superfície da língua (Suter *et al*., 2017; Bangi *et al*., 2019).

A língua consiste de uma complexa rede tridimensional de fibras musculares esqueléticas, envolvendo fibras intrínsecas e extrínsecas (Felton *et al*., 1985). Seu revestimento externo é constituído por estruturas papilares, cuja função pode ser mecânica ou gustativa (Suter *et al*., 2017; Bangi *et al*., 2019). As papilas filiformes apresentam-se em maior quantidade sobre o dorso da língua, e são essencialmente responsáveis pela função tátil e sensorial. Os sabores, relacionados à percepção gustativa, podem ser identificados a partir de papilas fungiformes, localizadas principalmente na extremidade anterior da língua, e circunvaladas, distribuídas sobre a região posterior da mesma. Por fim, sobre a porção lateral da língua encontram-se as papilas foliadas, as quais desempenham tanto a função tátil quanto gustativa (Snyder & Bartoshuk, 2016).

Além da função gustativa, a língua exerce importante papel sobre as funções sensorial e mastigatória (Bordoni *et al*., 2018). Devido a sua natureza muscular, a língua auxilia a movimentação do bolo alimentar durante a mastigação (Hori *et al*., 2006) e deglutição (Kondoh *et al*., 2015). Para isso, os receptores sensoriais orais percebem as características físicas dos alimentos e iniciam a coordenação das funções orais motoras, preparando o bolo alimentar para deglutição (Hirano *et al*., 2004). Uma vez que o alimento adquire partículas em tamanho adequado para sua ingestão, informações do sistema sensorial oral são enviadas ao sistema nervoso, impulsionando o bolo alimentar em direção ao esôfago (Kieser *et al*., 2014). Desta forma, pode-se sugerir que os receptores sensoriais presentes na superfície da língua atuem como componente chave na EO durante a mastigação e deglutição dos diferentes tipos de alimentos. Em que pese a importância da EO sobre a função mastigatória (Hirano *et al*., 2004; Fujii *et al*., 2011; Steele *et al*., 2014) poucos são os relatos na literatura sobre a papel da língua nesta atividade sensorial.

A língua, entretanto, pode apresentar alterações no padrão das estruturas papilares, chamadas alterações de normalidade da língua. As alterações de normalidade da língua mais prevalentes na população adulta são glossite migratória benigna (língua geográfica), língua fissurada e língua pilosa (Zanata *et al*., 2014; Toum *et al*., 2018), sendo que as duas primeiras podem aparecer em conjunto em muitos pacientes (Scariot *et al*., 2017; Al Qahtami *et al*., 2019). A glossite migratória benigna caracteriza-se por áreas desnudas

migratórias de diferentes formatos no dorso de língua (Goswami *et al*., 2012; Honamand *et al*., 2013), representada pela perda de papilas filiformes (Dafar *et al*., 2016; Scariot *et al*., 2017). A língua fissurada é determinada por alteração papilar devido à presença de sulcos e fissuras, tanto no dorso como na região lateral da língua (Goswami *et al*., 2012; Honamand *et al*., 2013). Por outro lado, o crescimento incomum de papilas filiformes nos dois terços anteriores da língua e o aumento expressivo da produção de queratina está relacionada ao tabagismo, caracterizando a língua pilosa (Mangold *et al*., 2016; Mainville, 2019). Uma vez que existem mudanças nas estruturas papilares, pode-se supor que as alterações de normalidade descritas poderiam ser também capazes de alterar os receptores sensoriais e gustativos, influenciando assim a EO e a percepção gustativa nestes indivíduos. Não existem, entretanto, estudos que relacionam a função sensorial oral à alterações de normalidade de língua.

Sabe-se que a EO é inversamente proporcional à idade (Grasso & Catalanatto, 1979; Dalaya, 2014; Bangcuyo *et al*., 2017), uma vez que a acuidade motora para manipulação intraoral dos objetos é menor em indivíduos idosos (Park *et al*., 2017). Além disso, a perda dentária reduz a EO, em decorrência da perda da propriocepção do ligamento periodontal (Litvak *et al*., 1971; Fukutake *et al*., 2019). Deste modo, a função sensorial oral assume importante papel quando da reabilitação oral de pacientes total ou parcialmente desdentados (Gnanasambandam *et al*., 2019), pois pacientes que apresentam maior sensibilidade ao teste de EO, ou seja, maiores pontuações, podem apresentar dificuldades de adaptação quando da instalação de novas próteses (Gnanasambandam *et al*., 2019).

A utilização de próteses totais (PTs) altera a resposta sensorial do paciente (Gnanasambandam *et al*., 2019), e estudos sobre o efeito do recobrimento do palato sobre a EO demonstram resultados diametralmente opostos, expondo acentuada controvérsia sobre o tema. Segundo alguns autores, o recobrimento do palato não influencia a percepção sensorial oral (Grasso & Catalanatto, 1979; Kumamoto *et al*., 2010; Meenakshi *et al*., 2014), pois as papilas presentes no dorso de língua seriam as principais mediadoras da função sensorial (Dalaya *et al*., 2014). No entanto, outros estudos revelam redução da EO frente ao recobrimento do palato (Kaiba *et al*., 2006; Ikbal *et al*., 2017), devido a possível restrição do movimento lingual imposta pelo recobrimento palatino, e alteração do feedback tátil de receptores presentes na superfície da língua (Kaiba *et al*., 2006; Steele *et al*., 2014; Massarelli *et al*., 2017). Considerando que a EO é essencial para o bom funcionamento do sistema estomatognático (Gnanasambandam *et al*., 2019), a influência do recobrimento palatino sobre a EO poderá ser utilizada para aumentar a previsibilidade do resultado do tratamento protetico.

A EO é avaliada por meio do reconhecimento oral de peças de seis diferentes formas geométricas agrupadas de acordo com a sua similaridade: *(1)* quadrado e retângulo;

(2) círculo e elipse; e *(3)* triângulo e semi-círculo, confeccionadas em resina acrílica (Kumamoto *et al*., 2010; Fukutake *et al*., 2019) ou alimentos naturais, como cenoura crua (Hirano *et al*., 2004; Meenakshi *et al*., 2014), e ainda podem ter dimensões aproximadas de 8 x 8 x 2mm, obtidas a partir de cortes feitos com matrizes metálicas. Cada peça é aleatoriamente colocada sobre o dorso da língua e, após a identificação da sua forma, o indivíduo seleciona em um quadro com a representação gráfica de todas as formas qual é a forma geométrica correspondente àquela peça que está em sua língua (Hirano *et al*., 2004).

A função gustativa por sua vez também pode ser influenciada por diferentes fatores. Alterações sistêmicas como líquen plano e fibrose oral, caracterizadas pela presença de tecido queratinizado e lesões ulcerativas na mucosa oral levam à redução da percepção gustativa (Suter *et al*., 2017; Bangi *et al*., 2019). Existem ainda relatos na literatura de que o sexo feminino apresenta melhor função gustativa quando comparado ao masculino, basicamente devido à flutuações hormonais (Yoshinaka *et al*., 2007) relacionadas ao estrogênio, que afetam a fisiologia de todo o corpo, inclusive da cavidade oral, acarretando em alterações de paladar e olfato (Yucel *et al*., 2002). Em adição, diferentes níveis de estrogênio parecem estar relacionados às mudanças morfológicas nas papilas circunvaladas, o que parece justificar as alterações na função gustativa feminina durante mudanças hormonais (Yucel *et al*., 2002), porém estudos ainda estão sendo desenvolvidos. Do mesmo modo, fatores externos como tabagismo e tratamento radioterápico, cujas consequências em comum são redução do fluxo salivar e inflamação dos tecidos bucais, acometem negativamente a percepção de sabores (Bangi *et al*., 2019). Entretanto, o efeito do recobrimento do palato sobre a percepção gustativa também apresenta resultados contraditórios. Segundo alguns autores, a presença de PTs não influencia a função gustativa, uma vez que a língua exerceria papel fundamental sobre o paladar (Ghaffari *et al*., 2009; Suter *et al*., 2021). No entanto, outro estudo relata redução da percepção gustativa frente ao recobrimento do palato, sendo que este resultado pode estar associado tanto à cobertura dos receptores presentes nos tecidos orais, bem como à redução da função gustativa devido à idade (Yoshinaka *et al*., 2007). Apesar dos estudos anteriores referentes à função gustativa, não existem relatos na literatura que associam a percepção gustativa à alterações de normalidade de língua. Além disso, a influência do recobrimento do palato sobre a mesma ainda é controversa.

Com base no que foi apresentado, o objetivo deste estudo foi verificar se alterações de normalidade da língua podem influenciar a EO e a função gustativa em indivíduos com e sem recobrimento do palato.

2 ARTIGOS

Este trabalho foi realizado no formato alternativo, conforme a Informação CCPG/001/2015, da Comissão Central de Pós-Graduação (CCPG) da Universidade Estadual de Campinas.

O artigo 2.1, intitulado “Palatal coverage and oral stereognosis: A systematic review and meta-analysis”, foi submetido à publicação no periódico *Journal of Prosthetic Dentistry.*

O artigo 2.2, intitulado “Potential effects of tongue lesions and palatal coverage on oral sensory functions”, foi submetido à publicação no periódico *Special Care in Dentistry.*

2.1 Artigo: Palatal coverage and oral stereognosis: A systematic review and meta-analysis*

SYSTEMATIC REVIEW

Palatal coverage and oral stereognosis: a systematic review and meta-analysis

ABSTRACT

Statement of problem: Complete denture wearers present reduced sensory function compared to dentate patients due to the loss of periodontal receptors. However, the role of the palatal receptors on such function is still controversial.

Purpose: This review evaluated the influence of palatal coverage associated with complete dentures, or palatal devices, on oral stereognosis in edentulous or dentate adults.

Material and Methods: Eight major literature databases and the non-peer-reviewed literature were searched up to December of 2021. Randomized clinical trials and non-randomized clinical trials comparing oral stereognosis in edentulous or dentate participants using conventional complete dentures or implant-supported prostheses, or those using palatal devices, were included. Bias was assessed with Cochrane tools (ROBINS-I and RoB 2.0). Meta-analyses were conducted to compare oral stereognosis before versus after palatal coverage (P=.05). Certainty of the evidence was verified by the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach.

Results: Of 14 included studies, the risk of bias was considered low for 9 studies and moderate for 5 studies. Despite the very low certainty of evidence, meta-analyses showed no differences on oral stereognosis immediately after complete denture insertion [standardized mean difference (SMD)=0.302; 95% confidence interval (CI): -0.124, 0.728; P=.165; I^2=92.4%]. OS scores improved after≥1 month of complete denture use compared to initial evaluations without them. Qualitative analysis indicated that OS was not influenced by palatal coverage shortly after complete denture installation and that OS scores improved after prosthesis use over time.

Conclusions: OS improves with use of a palate-covering prosthesis over time. However, due the very low certainty of evidence, such statement must be cautionary interpreted.

CLINICAL IMPLICATIONS

This review shows that oral stereognosis skills improve with experience after denture installation, which is relevant for predictability of the rehabilitation process.

Keywords: Denture; palatal device; stereognosis; palatal coverage.

*Formatado de acordo com as normas da Journal of Prosthetic Dentistry

INTRODUCTION

Oral stereognosis (OS) is the ability to identify and distinguish objects in the oral cavity by way of sensory information perceived via mucosal membranous tissues.[1,2] OS could potentially involve stimulation of the great number of tactile receptors associated with the teeth, tongue, lips, and palate together with the application of motor actions.[3-6] People can use OS to identify objects based on memories from previous visual and tactile experiences.[5,6]

In dentate patients, OS is largely dependent on proprioception from the periodontal ligaments.[6] As a result of tooth loss, edentulous people do not have periodontal receptors and therefore have reduced oral sensory function relative to individuals with natural teeth.[4,7] In addition, palatal coverage with dental prostheses may affect OS, particularly in patients who wear conventional complete dentures,[8] though the data in the literature related to this possibility have been inconsistent.

The effect of palatal coverage on OS demonstrates opposite results, exposing a controversy on the subject. Some studies indicate that the palate area is not an effective mediator of OS and suggest that the tongue is the main structure responsible for OS.[9,10] It has even been suggested that patients treated with a maxillary complete denture prosthesis may present better OS owing to the prosthesis acting as a rigid surface against which the tongue can apply pressure during object examination.[9] In contrast, it has been suggested that palatal coverage may affect OS[9,11] due to altered palatal receptor feedback[6] or overall changes in the oral environment.[11-13] Notwithstanding, implant insertion has been shown to increase oral awareness in complete denture wearers[8,14] owing to better prosthesis retention and stability.[9]

The aim of this systematic review was to assess whether palate coverage influences OS. The focus question to be answered was: Does palatal coverage influence OS in dentate or edentulous patients?

MATERIAL AND METHODS

This systematic review protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO) database (number CRD42021225332) and followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement guidelines.[15] This study was developed in accordance with the PICO (patient/population/problem-intervention-comparison-outcome) model as follows: P, dentate or edentulous patients; I, full palatal coverage with dentures or palatal device; C, comparison of OS with versus without any type of palatal coverage; and O, OS measure. Randomized clinical trials (RCTs) and non-randomized clinical trials (N-RCTs) evaluating palatal coverage effects on OS were included. Studies that did not compare OS before versus after coverage or mention denture type, and those using orthodontic devices or prostheses without a total palatal coverage were excluded. Case reports, review articles, conference abstracts, experts' opinions, and studies presenting incomplete data were also excluded.

This review identified and included studies through the following electronic databases: MEDLINE via PubMed, Scopus, Web of Sciences, Embase, Cochrane Library, and LILACS (Latin American and Caribbean Health Sciences Literature database) via Virtual Health Library. A manual search was performed on references of included primary studies to identify potentially eligible studies not collated in the electronic database searches. The literature was searched in January 2021 and alerts were received from the databases until December 2021. Additionally, the grey literature was explored via Google Scholar and Open Grey. Finally, articles not available online, such as in press article, were obtained by contacting the authors by email (3 attempts). No restrictions on language, publication date, or follow-up period were imposed. An expert librarian guided the search strategy and provided search advise for each database (Table 1). References from database searches were exported into the Rayyan Intelligent Systematic Review platform (Rayyan Systems Inc.),[16] which was used for duplicate article removal and as a reference manager.

The initial study selection was performed independently by 2 researchers based on titles and abstracts. If the title and/or abstract did not provide sufficient information, or if an abstract was not available, articles were downloaded and analyzed in full to decide on their

eligibility. When additional data were needed, authors were contacted by email (3 attempts) to clarify any doubts related to eligibility. Subsequently, full-text articles were acquired, and 2 reviewers classified those who met inclusion criteria. Disagreements between reviewers in both phases were solved by discussion, and persistent conflicts were resolved with the study coordinator.

The following details were extracted from eligible studies using customized extraction forms: author(s), year of publication and country; study design; information about participants, including sample size and characteristics, such as age, gender, and dental arches condition; types of palatal coverage, such as complete dentures or palatal devices with full palatal coverage; OS test methodology, including material type, shape/form, evaluation times, and statistical analysis; results, with focus on palatal coverage influence or not on OS data; and conclusion. When additional data were needed, the authors were contacted by email for clarification (5 attempts to each author).

Two examiners evaluated the methodological quality of the included studies with Cochrane tools. Risk of bias in N-RTCs was evaluated with the Risk Of Bias In Non-randomized Studies (ROBINS-I) method,[17] which rates bias according to 7 domains: confounding factors; participant selection; intervention classification; deviations from intended interventions; incomplete outcomes; outcome measure(s); and selection bias of reported outcomes. Each domain was graded as low, moderate, serious, or critical risk of bias, or insufficient information. To be considered as a low risk, the study must have low risk grades in all domains. If at least 1 domain was judged to have moderate, serious or critical bias risk, the study was considered to have a moderate, serious or critical bias risk, respectively.

RCTs were evaluated with the revised version of the Cochrane Randomized Bias Risk Assessment Tool (RoB 2.0),[18] which assesses bias in 5 domains: randomization process; deviations from intended interventions; incomplete outcomes; outcome measures; and selection bias of reported outcomes. Each domain was graded as high risk of bias, some concerns, or a low risk of bias based on an established checklist of possible answers. For a

study to be considered low risk, it was required to have low risk grades in all domains. Studies with any combination of low risk of bias and some concerns were classified as having some concerns. If at least 1 domain was judged to have serious or critical bias risk, the study was considered to have a serious or critical bias risk, respectively.

The sample characteristics, type of palatal coverage, methods, and periods of OS assessment were evaluated to determine methodological heterogeneity across the studies. Because there were inter-study variations regarding the scales and methods for measuring OS, standardized mean difference (SMD) was chosen as the effect measure. Random-effects meta-analyses were performed to estimate OS score differences and corresponding 95% confidence intervals (CIs) between groups with and without palatal coverage (before-and-after comparisons). Since data from dependent groups were compared, an intra-participant correlation coefficient of 0.5 was assumed[18] . Subgroup analysis was conducted to test a possible influence of the period of evaluation on OS. Sensitivity analysis was performed to assess the robustness of the results. I^2 index value was calculated to assess statistical heterogeneity. All estimates were made in Comprehensive Meta-analysis 2.0 (Biostat, Englewood, NJ). A 5% significance level was applied. The certainty of evidence was determined with the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach.[19-21]

RESULTS

A flow diagram developed according to PRISMA guidelines is shown in Figure 1.[22] Briefly, the initial search identified 255 references; 101 duplicates were removed, leaving 154 potentially eligible studies. Title and abstract screening based on the above eligibility criteria excluded 122 records. Thus, 32 studies were selected for full-text reading, of which 18 were excluded. Specifically, 3 were excluded due to nonavailability of the full text after 3 author contact attempts and 15 were excluded for not meeting the eligibility criteria (14 did not compare OS before versus after denture insertion; and 1 did not disclose denture type).

The characteristics of the included studies are summarized in Table 2. Their publication years ranged from 1971 to 2020. The most common country of origin was India.[1,6,14,23] Three studies were RCTs[10,11,24] and the remaining 11 were N-RCTs.[1,6,14,23,25-31] Altogether, the studies included 974 participants aged between 20 to 91 years, with a majority being men (when gender was indicated). Type of palatal coverage was indicated in all of the included articles. Participants with conventional complete dentures, a palatal device manufactured for dentate volunteers, and implant-supported dentures were enrolled in 11 studies,[1,6,10,14,23,25-30] 4 studies,[11,24,25,29] and 1 study,[31] respectively. In all of the included studies, OS was evaluated through intraoral form identification. Acrylic resin was the most used material;[1,6,10,24,27,28] forms made of raw carrots,[11,23,26] polyethylene,[29] plastic,[31] and metal[14] were also used. Two studies did not mention the material used to perform the OS test.[25,30] In most studies,[6,10,14,24-26,28,29,31] OS was assessed once before and once after palatal coverage. In 5 studies, there were multiple OS tests at different times, 30 minutes to 6 months after installation of palate covering.[1,11,23,27,30]

Other variables besides palatal coverage that could influence OS results, such as systemic diseases,[6,27] were considered in only 2 of the included studies. In a study with 2 clinical groups [stroke patients and Parkinson disease patients], Pow et al[27] found that OS performance depended on lingual motor function, with shapes being recognized through manipulation.[27] Gnanasambandam et al[6] examined whether OS would be disrupted in diabetic participants, who have impaired oral sensory function.[6] In both studies, OS after palatal coverage was not found to be influenced significantly by the presence of disease.[6,27]

Of 11 N-RCTs subjected to ROBINS-I analysis, 2 were found to have a moderate risk of bias. Both were at risk of confounding factors due to carrying out volunteer selection involving an evaluation of their characteristics. The remaining 9 articles were classified as having a low risk of bias (Table 3). All 3 RCTs studies were classified as having some concerns (Rob 2.0) due to randomization concerns, principally related to how participants were distributed among study groups (Table 4).

All 14 studies included in this review reported no OS difference before versus after palatal coverage and suggested that the tongue was principally responsible for performing OS.[1,6,10,11,14,22-30] In most of the studies, OS was examined in edentulous patients with complete dentures.[1,6,14,22-29] Three of the studies assessed OS in dentate patients fitted with a full-palate-covering device made of acrylic resin[11,30] or baseplate wax.[22] Time with the device/complete denture was considered as a factor in OS in 5 studies.[1,11,23,27,30] Though different time periods were considered, better OS performance was consistently associated with greater time with the device/complete denture.[1,11,23,27,30] No differences in OS were found between healthy participants and patients with systemic diseases (stroke, Parkinson disease, or diabetes), but OS scores were higher after complete denture insertion and use for all participants.[6,27]

Six studies were not included in the quantitative synthesis[10,11,24,25,29,31] due to insufficient data. Of these, 4 did not report mean or standard deviation values, 1 did not include pre-palate-coverage data, and 1 provided separate OS information (score and time) by form shape used in the test, but did not report total OS scores. All 8 studies included in the quantitative synthesis enrolled adult (including elderly) edentulous participants with and without palatal coverage.[1,6,14,23,26-28,30] Subgroup analysis showed an influence of installation-to-evaluation time interval (immediately after installation versus a month or more of use) on OS performance (P=.002). Effect size estimates were calculated for each evaluation period separately (Fig. 2). Because data on OS without palate coverage for the studies[1,24,29] are the same at both assessment periods, pooled estimates combining all datasets were not performed, because this would have generated duplication of data for one of the groups. Immediately after complete denture installation, OS scores did not differ between with- and without-denture assessments (SMD=0.302; 95% CI: -0.124, 0.728; P=.165; I^2=92.4%). OS scores after≥1 month of denture use were better than scores at the initial evaluation (SMD=1.565; 95% CI: 0.899, 2.232; P<.001; I^2=85.9%). Excluding studies evaluating individuals with systemic conditions (stroke, Parkinson disease, and diabetes)[6,28] did not alter the direction or significance of the results (Fig. 3). Thus, these datasets were maintained in

the analysis. The certainty of evidence was classified as very low for both syntheses performed (Table 5). Risk of bias impacted certainty of evidence strongly because data from N-RCTs studies were used. Furthermore, results were inconsistent across the synthesized studies (I^2 values>75%). Finally, the estimates were imprecise due to the limited amount of data available for analysis.

DISCUSSION

For the first time to the best of our knowledge, this systematic review examined the influence of palatal coverage on OS under a variety of conditions, including in dentate individuals and in participants using various types of oral rehabilitation. The qualitative analysis of the present review revealed no differences in OS with versus without palatal coverage immediately after coverage onset. Similarly, meta-analysis showed no differences in OS with versus without palatal coverage in edentulous participants immediately after complete denture insertion. However, a relationship between OS and time of palatal coverage was found. After a month or more of using their dentures, participants exhibited better OS than they had shown in baseline measurements without the use of dentures. OS in participants with systemic diseases was not affected by palatal coverage.

OS requires motor activity to manipulate objects inside the oral cavity with consequent interaction with tactile receptors in the oral mucosa.[23] The oral cavity has extraordinarily high sensory innervation, which is mediated via the trigeminal nerve.[24] The tongue has been described as the primary source of information used in OS.[24] Although tactile receptors are present throughout the oral cavity, including in the palate, the majority of tactile receptors are on the tongue surface.[6] The receptor-rich tongue may thus be sufficient for shape recognition.[12] Moreover, it is possible that coverage of the palate with a complete denture may actually facilitate OS if complete denture wearers use the covered palate as a rigid support against which the tongue can manipulate objects.[6]

Regarding an influence of the timing of evaluation on OS, OS scores improved over time, with better performance being observed after 1 month[11,23] or 6 months[1] of use than

immediately after prosthesis installation. These observations could be explained by a learning effect, including repetition of the test,[1,11,23] which suggests that OS may be a skill that can be trained. Mantecchini et al[26] reported that there is typically a 1–3-month period of adaption to new dentures. Such adaptation may lead to an improved ability to manipulate objects compared to the edentulous scenario,[1,23,27] and correct rehabilitation may thus be an important factor in improving OS ability in edentulous patients.

Although characteristics of stroke (facial paralysis affecting the tongue and lower face),[28] diabetes (loss of tactile sensation and oral lesions),[2] and Parkinson disease (tremor in the hands, lips and tongue) could potentially affect OS, all 3 patient groups were found to develop better OS after complete denture insertion.[6,27] These findings suggest that OS may not be sensitive to systemic and neurodegenerative diseases.[6,27] These findings might be related to denture quality given that patients with these conditions require very well fitted prostheses, especially diabetic patients with altered sensitivity from neuropathy and microcirculatory disturbances.[6] Appropriate rehabilitation has been reported to be a factor that improves motor function after complete denture insertion.[6] Given that OS depends on movement of objects inside the mouth,[2] these data suggest that patients with the above diseases have intact tactile function. Effective pharmacological control of motor impairments associated with these conditions may contribute to better OS outcomes.[27]

All 3 included RCTs were classified as having a moderate risk of bias[10,11,24] due to insufficient information being provided about the randomization process. Meanwhile, 9 N-RCTs[1,6,14,23,25,26,28-30] were classified as having a low risk of bias and 2 N-RCTs[27,31] were found to have a moderate risk of bias, mainly due to problems related to participant selection. It is important to point out that according to the Cochrane's Handbook for Systematic Reviews of Interventions,[21] the meta-analysis can be performed with at least 2 studies, and the data of the current investigation showed improvement of OS over time after denture insertion. However, as the meta-analysis included few articles, and the certainty of evidence from these articles was very low, the results of this review must be interpreted with care.

The results of the current review report the influence of palatal coverage on OS of dentate and edentulous participants, which may present different oral sensory perception, due to proprioception via periodontal ligaments.[6-8] However, to evaluate the influence of palatal coverage in the OS of dentate individuals, the participants are instructed to manipulate the forms between the tongue and palate, avoiding other sensory receptors,[5,6,10,28,30] as the proprioception of periodontal ligaments.[6] Thus, dentate and edentulous patients were included in this review.

It should be highlighted that the present review have included studies with randomization process often not described, sample heterogeneity (varying age and systematic disease status), and different methodologies to determine OS outcome, which could figure as a limitation. In addition, the replacement of old prostheses by new ones, and the comparison of OS between complete denture wearers and those who had never previously worn a maxillary complete denture may influence OS results[6]. For this reason, data should be interpreted with caution. Furthermore, intervention blinding was impossible. Thus, future RCTs with a standardized methodology for assessing OS should be conducted with full palatal coverage devices. Finally, to produce more reliable and comparable findings and to allow stronger conclusions, the time of use of the prostheses should be collected and OS should be compared across similarly aged individuals with and without systemic conditions that are associated with motor complications.

CONCLUSION

Situated on the findings of this systematic review and meta-analysis, the following conclusions were drawn:

1. OS is not influenced by palatal coverage when evaluated immediately after prosthesis or palatal device installation.

2. OS improves with dental prostheses use over time.

However, due to the very low certainty of evidence, the present data must be carefully interpreted.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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Table 1. Database search strategy (January to December 2021).

Data Base	Search strategy
PubMed	#1 "Dental Prosthesis"[MeSH Terms] OR Denture[MeSH Terms] OR Dentures[MeSH Terms] OR "Denture, complete"[MeSH Terms] OR "Denture, complete, immediate"[MeSH Terms] OR "Denture, complete, lower"[MeSH Terms] OR "Denture, complete, upper"[MeSH Terms] OR "Denture, partial"[MeSH Terms] OR "Denture, partial, removable"[MeSH Terms] OR "Dental prosthesis, implant supported"[MeSH Terms] OR "Denture, overlay"[MeSH Terms] OR "Dental Prosthesis"[Title/Abstract] OR Denture[Title/Abstract] OR Dentures[Title/Abstract] OR "Denture, complete"[Title/Abstract] OR "Denture, complete, immediate"[Title/Abstract] OR "Denture, complete, lower"[Title/Abstract] OR "Denture, complete, upper"[Title/Abstract] OR "Denture, partial"[Title/Abstract] OR "Denture, partial, removable"[Title/Abstract] OR "Dental prosthesis, implant supported"[Title/Abstract] OR "Denture, overlay"[Title/Abstract] OR "Prosthesis, Dental"[Title/Abstract] OR "Dental Prostheses"[Title/Abstract] OR "Prostheses, Dental"[Title/Abstract] OR "Complete denture"[Title/Abstract] OR "Complete dentures"[Title/Abstract] OR "Denture, complete"[Title/Abstract] OR "Partial denture"[Title/Abstract] OR "Partial dentures"[Title/Abstract] OR "Dentures, partial"[Title/Abstract] OR "Removable partial denture"[Title/Abstract] OR "Denture, removable partial"[Title/Abstract] OR "Dentures, removable partial"[Title/Abstract] OR "Partial denture, removable"[Title/Abstract] OR "Partial dentures, removable"[Title/Abstract] OR "Removable partial dentures"[Title/Abstract] OR "Dental prosthesis, Implant supported"[Title/Abstract] OR "Implant-supported dental prosthesis"[Title/Abstract] OR "Dental prostheses, Implant-supported"[Title/Abstract] OR "Implant supported dental prosthesis"[Title/Abstract] OR "Implant-supported dental prostheses"[Title/Abstract] OR "Prostheses, Implant-supported dental"[Title/Abstract] OR "Prosthesis, Implant-supported dental"[Title/Abstract] OR "Denture, Implant-supported"[Title/Abstract] OR "Denture, Implant supported"[Title/Abstract] OR "Implant-supported denture"[Title/Abstract] OR "Dentures, Implant-supported"[Title/Abstract] OR "Implant supported denture"[Title/Abstract] OR "Implant-supported

	dentures”[Title/Abstract] OR "Prosthesis dental, Implant-supported”[Title/Abstract] OR "Dental, Implant-supported prosthesis”[Title/Abstract] OR "Dentals, Implant-supported prosthesis”[Title/Abstract] OR "Implant-supported prosthesis dental”[Title/Abstract] OR "Implant-supported prosthesis dentals”[Title/Abstract] OR "Prosthesis dental, Implant supported”[Title/Abstract] OR "Prosthesis dentals, Implant supported”[Title/Abstract] OR "Dentures, overlay"[Title/Abstract] OR "Overlay Denture"[Title/Abstract] OR "Overlay Dentures"[Title/Abstract] OR "Overdenture"[Title/Abstract] OR "Overdentures"[Title/Abstract] OR "Denture wearer"[Title/Abstract] OR "Denture wearers"[Title/Abstract] OR "Palatal device"[Title/Abstract] OR "Full palatal coverage"[Title/Abstract] OR "Palatal coverage"[Title/Abstract] OR "Palatal plate"[Title/Abstract] #2 Stereognosis[MeSH Terms] OR Stereognosis[Title/Abstract] OR (Stereognoses[Title/Abstract] OR "Oral stereognosis"[Title/Abstract] OR "Oral stereognostic ability"[Title/Abstract] OR "Oral stereognostic test"[Title/Abstract] OR "Oral stereognostic proficiency"[Title/Abstract] OR "Oral sensory function"[Title/Abstract] OR "Oral sensory ability"[Title/Abstract] OR "Oral sensorimotor function"[Title/Abstract] OR "Oral perception"[Title/Abstract] OR "Stereognosis test"[Title/Abstract] OR “Oral tactile ability”[Title/Abstract] #1 AND #2
Scopus	#1 INDEXTERMS ({Dental Prosthesis} OR Denture OR Dentures OR {Denture, complete} OR {Denture, complete, immediate} OR {Denture, complete, lower} OR {Denture, complete, upper} OR {Denture, partial} OR {Dental, partial, removable} OR {Dental Prosthesis, Implant Supported} OR {Denture, Overlay})) OR (TITLE-ABS-KEY ({Dental Prosthesis} OR {Denture} OR {Dentures} OR {Denture, complete} OR {Denture, complete, immediate} OR {Denture, complete, lower} OR {Denture, complete, upper} OR {Denture, partial} OR {Dental, partial, removable} OR {Dental Prosthesis, Implant Supported} OR {Denture, Overlay} OR {Prosthesis, Dental} OR {Dental Prostheses} OR {Prostheses, Dental} OR {Complete denture} OR {Complete dentures} OR {Dentures,

	complete} OR {Dentures, Partial} OR {Partial Denture} OR {Partial Dentures} OR {Removable Partial Denture} OR {Denture, Removable Partial} OR {Dentures, Removable Partial} OR {Partial Denture, Removable} OR {Partial Dentures, Removable} OR {Removable Partial Dentures} OR {Dental Prosthesis, Implant Supported} OR {Implant-Supported Dental Prosthesis} OR {Dental Prostheses, Implant-Supported} OR {Implant Supported Dental Prosthesis} OR {Implant-Supported Dental Prostheses} OR {Prostheses, Implant-Supported Dental} OR {Prosthesis, Implant-Supported Dental} OR {Denture, Implant-Supported} OR {Denture, Implant Supported} OR {Implant-Supported Denture} OR {Dentures, Implant-Supported} OR {Implant Supported Denture} OR {Implant-Supported Dentures} OR {Prosthesis Dental, Implant-Supported} OR {Dental, Implant-Supported Prosthesis} OR {Dentals, Implant-Supported Prosthesis} OR {Implant-Supported Prosthesis Dental} OR {Implant-Supported Prosthesis Dentals} OR {Prosthesis Dental, Implant Supported} OR {Prosthesis Dentals, Implant-Supported} OR {Dentures, Overlay} OR {Overlay Denture} OR {Overlay Dentures} OR Overdenture OR Overdentures OR {Denture wearer} OR {Denture wearers} OR {Palatal device} OR {Full palatal coverage} OR {Palatal coverage} OR {Palatal plate} #2 INDEXTERMS (stereognosis)) OR (TITLE-ABS-KEY (Stereognosis OR Stereognoses OR {Oral stereognosis} OR {Oral stereognostic ability} OR {Oral stereognostic test} OR {Oral stereognostic proficiency} OR {Oral sensory function} OR {Oral sensory ability} OR {Oral sensorimotor function} OR {Oral perception} OR {Stereognosis test} OR {Oral tactile ability} #1 AND #2
Web of Science	#1 TS=(“Dental Prosthesis” OR Denture OR Dentures OR “Denture, complete” OR “Denture, complete, immediate” OR “Denture, complete, lower” OR “Denture, complete, upper” OR “Denture, partial” OR “Dental, partial, removable” OR “Dental Prosthesis, Implant Supported” OR “Denture, Overlay” OR “Prosthesis, Dental” OR “Dental Prostheses” OR “Prostheses, Dental” OR “Complete denture” OR “Complete dentures” OR “Dentures, complete” OR “Dentures, Partial” OR “Partial Denture” OR

	"Partial Dentures" OR "Removable Partial Denture" OR "Denture, Removable Partial" OR "Dentures, Removable Partial" OR "Partial Denture, Removable" OR "Partial Dentures, Removable" OR "Removable Partial Dentures" OR "Dental Prosthesis, Implant Supported" OR "Implant-Supported Dental Prosthesis" OR "Dental Prostheses, Implant-Supported" OR "Implant Supported Dental Prosthesis" OR "Implant-Supported Dental Prostheses" OR "Prostheses, Implant-Supported Dental" OR "Prosthesis, Implant-Supported Dental" OR "Denture, Implant-Supported" OR "Denture, Implant Supported" OR "Implant-Supported Denture" OR "Dentures, Implant-Supported" OR "Implant Supported Denture" OR "Implant-Supported Dentures" OR "Prosthesis Dental, Implant-Supported" OR "Dental, Implant-Supported Prosthesis" OR "Dentals, Implant-Supported Prosthesis" OR "Implant-Supported Prosthesis Dental" OR "Implant-Supported Prosthesis Dentals" OR "Prosthesis Dental, Implant Supported" OR "Prosthesis Dentals, Implant-Supported" OR "Dentures, Overlay" OR "Overlay Denture" OR "Overlay Dentures" OR Overdenture OR Overdentures OR "Denture wearer" OR "Denture wearers" OR "Palatal device" OR "Full palatal coverage" OR "Palatal coverage" OR "Palatal plate") #2 TS=(Stereognosis OR Stereognoses OR "Oral stereognosis" OR "Oral stereognostic ability" OR "Oral stereognostic test" OR "Oral stereognostic proficiency" OR "Oral sensory function" OR "Oral sensory ability" OR "Oral sensorimotor function" OR "Oral perception" OR "Stereognosis test" OR "Oral tactile ability") #1 AND #2
Embase	#1 'denture'/mj OR 'tooth prosthesis'/mj OR 'implant-supported denture'/mj OR 'removable partial denture'/mj OR 'complete denture'/mj OR 'complete immediate denture'/mj OR 'complete lower denture'/mj OR 'complete upper denture'/mj OR 'overlay denture'/mj OR 'partial denture'/mj OR 'dental prosthesis':ti,ab,kw OR 'denture':ti,ab,kw OR 'dentures':ti,ab,kw OR 'denture complete':ti,ab,kw OR 'denture complete immediate':ti,ab,kw OR 'denture complete lower':ti,ab,kw OR 'denture complete upper':ti,ab,kw OR 'denture partial':ti,ab,kw OR 'dental partial removable':ti,ab,kw OR 'denture overlay':ti,ab,kw OR 'prosthesis dental':ti,ab,kw OR 'dental prostheses':ti,ab,kw OR 'prostheses

	dental':ti,ab,kw OR 'complete denture':ti,ab,kw OR 'complete dentures':ti,ab,kw OR 'dentures complete':ti,ab,kw OR 'dentures partial':ti,ab,kw OR 'partial denture':ti,ab,kw OR 'partial dentures':ti,ab,kw OR 'removable partial denture':ti,ab,kw OR 'denture removable partial':ti,ab,kw OR 'dentures removable partial':ti,ab,kw OR 'partial denture removable':ti,ab,kw OR 'partial dentures removable':ti,ab,kw OR 'removable partial dentures':ti,ab,kw OR 'dental prosthesis implant supported':ti,ab,kw OR 'dental prostheses implant supported':ti,ab,kw OR 'implant supported dental prosthesis':ti,ab,kw OR 'implant supported dental prostheses':ti,ab,kw OR 'prostheses implant supported dental':ti,ab,kw OR 'prosthesis implant supported dental':ti,ab,kw OR 'denture implant supported':ti,ab,kw OR 'dentures implant supported':ti,ab,kw OR 'implant supported denture':ti,ab,kw OR 'implant supported dentures':ti,ab,kw OR 'dental implant supported prosthesis':ti,ab,kw OR 'dentals implant supported prosthesis':ti,ab,kw OR 'implant supported prosthesis dental':ti,ab,kw OR 'implant supported prosthesis dentals':ti,ab,kw OR 'prosthesis dental implant supported':ti,ab,kw OR 'prosthesis dentals implant supported':ti,ab,kw OR 'dentures overlay':ti,ab,kw OR 'overlay denture':ti,ab,kw OR 'overlay dentures':ti,ab,kw OR 'overdenture':ti,ab,kw OR 'overdentures':ti,ab,kw OR 'denture wearer':ti,ab,kw OR 'denture wearers':ti,ab,kw OR 'palatal device':ti,ab,kw OR 'full palatal coverage':ti,ab,kw OR 'palatal coverage':ti,ab,kw OR 'palatal plate':ti,ab,kw #2 'pattern recognition'/mj OR stereognosis:ti,ab,kw OR stereognoses:ti,ab,kw OR 'oral stereognosis':ti,ab,kw OR 'oral stereognostic ability':ti,ab,kw OR 'oral stereognostic test':ti,ab,kw OR 'oral stereognostic proficiency':ti,ab,kw OR 'oral sensory function':ti,ab,kw OR 'oral sensory ability':ti,ab,kw OR 'oral sensorimotor function':ti,ab,kw OR 'oral perception':ti,ab,kw OR 'stereognosis test':ti,ab,kw OR 'oral tactile ability':ti,ab,kw #1 AND #2
Cochrane Library	#1 MeSH descriptor: [Dental Prosthesis] explode all trees #2 MeSH descriptor: [Dentures] explode all trees #3 MeSH descriptor: [Denture, Complete] explode all trees

#4 MeSH descriptor: [Denture, Complete, Immediate] explode all trees

#5 MeSH descriptor: [Denture, Complete, Lower] explode all trees

#6 MeSH descriptor: [Denture, Complete, Upper] explode all trees

#7 MeSH descriptor: [Denture, Partial] explode all trees

#8 MeSH descriptor: [Dental Prosthesis, Implant-Supported] explode all trees

#9 MeSH descriptor: [Denture, Overlay] explode all trees

#10 #1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9

#11 "Dental Prosthesis" OR Denture OR Dentures OR "Denture, complete" OR "Denture, complete, immediate" OR "Denture, complete, lower" OR "Denture, complete, upper" OR "Denture, partial" OR "Dental, partial, removable" OR "dental prosthesis, Implant suppORted" OR "Denture, overlay" OR "Prosthesis, Dental" OR "Dental Prostheses" OR "Prostheses, Dental" OR "Complete denture" OR "Complete dentures" OR "Dentures, complete" OR "Dentures, Partial" OR "Partial Denture" OR "Partial Dentures" OR "Removable Partial Denture" OR "Denture, Removable Partial" OR "Dentures, Removable Partial" OR "Partial Denture, Removable" OR "Partial Dentures, Removable" OR "Removable Partial Dentures" OR "Dental Prosthesis, Implant Supported" OR "Implant Supported Dental Prosthesis" OR "Dental Prostheses, Implant Supported" OR "Implant Supported Dental Prosthesis" OR "Implant Supported Dental Prostheses" OR "Prostheses, Implant Supported Dental" OR "Prosthesis, Implant Supported Dental" OR "Denture, Implant Supported" OR "Denture, Implant Supported" OR "Implant Supported Denture" OR "Dentures, Implant Supported" OR "Implant Supported Dentures" OR "Prosthesis Dental, Implant Supported" OR "Dental, Implant Supported Prosthesis" OR "Dentals, Implant Supported Prosthesis" OR "Implant Supported Prosthesis Dental" OR "Implant Supported Prosthesis Dentals" OR "Prosthesis Dental, Implant Supported" OR "Prosthesis Dentals, Implant Supported" OR "Denture wearer" OR "Denture wearers" OR "Palatal device" OR "Full palatal coverage" OR "Palatal coverage" OR "Palatal plate"

#12 #10 OR #11

#13 MeSH descriptor: [Stereognosis] explode all trees

	#14 Stereognosis OR Stereognoses OR "Oral stereognosis" OR "Oral stereognostic ability" OR "Oral stereognostic test" OR "Oral stereognostic proficiency" OR "Oral sensory function" OR "Oral sensory ability" OR "Oral sensorimotor function" OR "Oral perception" OR "Stereognosis test" OR "Oral tactile ability" #15 #13 OR #14 #16 #12 AND #15
Lilacs	#1 mh:("Dental Prosthesis" OR "Dentures" OR "Denture, Complete" OR "Denture, Complete, Immediate" OR "Denture, Complete, Lower" OR "Denture, Complete, Upper" OR "Denture, Partial" OR "Denture, Partial, Removable" OR "Dental Prosthesis, Implant-Supported" OR "Denture, Overlay") #2 mh:("Stereognosis") #1 AND #2

Table 2. Characteristics of included articles.

Author(s), year (country)	Study design	Participants (P)			Intervention (I)		Outcome (O)			
		Participants	Sample size	Age	Palate cover	Dentures	Method to assess OS	Evaluation times	Results	Conclusion
Litvak et al., 1971 (USA)	N-RCT	G1: Dentate	42 (GNI)	20–72 y	G1: Baseplate wax	New CDs made for the study	Identification of ten forms, varying degrees of surface and basic-form alterations. OS scored as percent answers correct	W/o baseplate wax (T0), w baseplate wax (T1)	69.5 (T0); 55.0 (T1) for 20–31 y; 55.5 (T0); 42.1 (T1) for 50–72 y	OS in edentulous subjects greatest w both Max. and Mand. CD in place
		G2: Edentulous	48 (GNI)	50–75 y	G2: CD			No CDs (T0), Max. CD (T1); Mand. CD (T2), both (T3)	37.4 (T0), 40.0 (T1), 41.3 (T2), 44.9 (T3)	
Garrett et al. 1994 (USA)*	N-RCT	Edentulous	53 M/1 F	48–85 y	CD	New CDs made for the study	Identification of 10 shapes (raw carrot). 3-point scale, 100% correct, 40 points	W/o CD (T0) and w CD (T1)	T0 = 10.2 (SD 6.6); T1 = 9.5 (SD 6.7)	Trend of OS reduction after CD removal
Mantecchini et al., 1998 (Italy)	Controlled before-and-after	G1: Edentulous w new CDs	22 M/15 F	49–86 y	CD	New CDs made for the study	Identification of 10 shapes of different size (Plexiglass). OS score 0–10, number of correct identifications	w/o CD (T0) and w CD 1~3 mos. posttreatment (T1)	T0: 5.78 (SD 2.04); T1: 7.65 (SD 2.03)	CD palatal coverage did not reduce OS; correct restoration can improve OS
		G2: Edentulous w old CDs	19 (GNI)	49–86 y				w/o CD (T0) and w CD (T1)	T0: 5.78 (SD 2.04); T1: 5.89 (SD 2.33)	
Pow et al., 2001 (China)*	N-RCT	G1: Edentulous w stroke	14 M/21 F	mean 71.2 y	CD	New CDs were not made for the study	Identification of 10 objects (AR). 3-point scale, 100% correct, 40 points	Two times: w/o (T0) and w CD (T1)	T0: 6.7 (SD 4.4); T1: 9.0 (SD 4.9)	OS did not differ between partially dentate and edentulous CD wearers; OS higher at T1
		G2: Edentulous w PD	15 M/20 F	mean 71.4 y					T0: 10.7 (SD 3.1); T1:11.9 (SD 2.9)	
Kaiba et al., 2006 (Japan)	Controlled before-and-after	Dentate	12 M/8 F	24–31 y	HC-AR palatal device	Not applicable	Identification of 12 shapes (raw carrot); 3 trials for each form. Total score (max 72, 36 trials) used as OS score	W/o palatal coverage (T0), immediately after palatal coverage (T1), 3 d after (T2) and 1 wk after (T3)	OS not influenced by device but was influenced by test repetition.	Palatal coverage decreased OS; well-adapted full coverage CDs recommended
Ikebe et al., 2007 (Japan)*	RCT	Edentulous	13 M/17 F	66–80 y	CD	New CDs were not made for the study	Identification of 12 shapes (AR), each presented twice. 3-point scale, 100% correct, 48 points	W/o (T0) and w CD (T1)	Mean 34 (SD 9) (T1)	Oral sensory function similar between elderly fully dentate persons v. CD wearers
Kawagishi et al., 2009 (Japan)	N-RCT	G1: Young adults	182 M/87 F	23–32 y	G1: Mouth-guard, ethylene vinyl acetate copolymer	New CDs were not made for the study	Identification of 20 shapes (polyethylene). OS scored as a percent responses correct	W (T0) and w/o (T1) palatal coverage	G1: 16.4 (T0) and 16.5 (T1)	Method informs development of rehabilitation method targeting recovery of tongue stereognosis
		G2: Seniors	9 M/51 F	66–91 y	G2: Full dentures				G2: 10.3 (T0) and 10.8 (T1)	

Amarasena et al., 2010 (Sri Lanka)	N-RCT	Edentulous	8 M/8 F	60–70 y	CD	New CDs were made for the study	Identification of 5 sizes of steel spheres. OS scored as percent responses correct	Before CD insertion (T0), 30 min after insertion (T1), and after 1 month of CD use (T2)	T0 = 47.5 (SD 9.979). T1 = 41.25 (SD 5.313). T2 = 58.75 (SD 4.990)	OS improved in experienced and non-experienced CD wearers after 1 mo. of use, showing learning
Kumamoto et al., 2010 (Japan)	RCT	Dentate	10 M/5 F	22–32 y	2 HP-AR devices: horseshoe-shaped; plate-B (gingival cuff to "ah" line)	Not applicable	Identification of 12 large and small geometric shapes (HP-AR). 3-point scale, 100% correct, 36 points	Without plate (T0), w plate-A (T1) and w plate-B (T2)	Not reported	OS not changed by plates
Dalaya, 2014 (India)*	N-RCT	Edentulous	40 (GNI)	30–70 y	CD	New CDs were made for the study	Identification of 7 forms (metal) w shape and surface alterations. OS scored as percent responses correct	W/o CD (T0) and w CD (T1)	T0: 48.94 (SD 21.41); T1: 36.9 (SD 20.45)	Palatal coverage did not affect OS
Meenakshi et al., 2014 (India)	Controlled before-and-after	Edentulous	30 (GNI)	55–60 y	CD	New CDs were made for the study	Identification of 6 shapes (raw carrot). 3-point scale, 100% correct, 12 points	Before CDs (T0), 30 min after CD insertion (T1), after 1 mo. of CD use (T2)	T0 = 9.33 (SD 1.63). T1 = 11.33 (SD 0.92). T2 = 11.86 (SD 0.92)	Covering the palatal mucosa with a CD did not reduce OS
Gnanasamban dam et al., 2019 (India)	N-RCT	G1: Diabetic edentulous	35 (GNI)	35–84 y	CD	New CDs were made for the study	Identification of 12 forms (acrylic resin) in two sizes. 3-point scale, 100% correct, 12 points	W/o CD (T0) and w CD (T1)	T0 = 12.43 (SD 3.93) T1 = 13.89 (SD 4.04)	Diabetic CD wearers showed lower OS than nondiabetics without palatal coverage. Both groups' OS scores increased with CDs
		G2: Non-diabetic edentulous	35 (GNI)						T0 = 14.82 (SD 4.44). T1 = 15.71 (SD 5.39)	
Kilic et al., 2019 (Turkey)	N-RCT	G1: bar attached Max-IS CD	12 (GNI)	mean 59.5 y	Palatal coverage associated w Max-IS CDs w bar or magnetic attachments	New CDs were not made for the study	Identification of 10 plastic samples. OS was evaluated by answer time	Without CD (T0) and with CD (T1)	Not reported	No correlation between patient satisfaction and OS in patients w implant-supported CDs
		G2: magnet attached Max-IS CD	14 (GNI)	mean 61.8 y						
		G3: Max-IS CD w bar attachments, palate exposed	18 (GNI)	mean 56.2 y						
Mary et al., 2020 (India)	Controlled before-and-after	Edentulous	70 (GNI)	50–70 y	CD	New CD were made for the study	Identification of 6 shapes (HCAR). 3-point scale, 100% correct, 12 points	Before CD insertion (T0); after CD insertion (T1); 6 months after T1 (T2)	T0 = 6.5 (SD 2.2) T1 = 9.1 (SD 1.9). T2 = 10.8 (SD 1.2)	Rehabilitation w CDs can improve OS

Table 3. Results of bias risk assessment of non-randomized clinical trials with ROBINS-I tool.

Study	Risk by domain							Risk of bias
	Confusion	Selection of participants	Classification of interventions	Deviation from interventions	Data hiding	Measurement of results	Reported results	
Litvak et al. (1971)	+	+	+	+	+	+	+	+
Garrett et al. (1994)	+	+	+	+	+	+	+	+
Mantechinni et al. (1998)	?	?	+	+	+	+	+	?
Pow et al. (2001)	+	+	+	+	+	+	+	+
Kawagishi et al. (2009)	+	+	+	+	+	+	+	+
Amarasena et al. (2010)	+	+	+	+	+	+	+	+
Dalaya (2014)	+	+	+	+	+	+	+	+
Meenakshi et al. (2014)	+	+	+	+	+	+	+	+
Gnanasambandam et al. (2019)	+	+	+	+	+	+	+	+
Kilic et al. (2019)	+	?	+	+	+	+	+	?
Mary et al. (2020)	+	+	+	+	+	+	+	+

Judgement (risk of bias):

+ Low

? Moderate

Table 4. Results of bias risk assessment of randomized clinical trials with RoB 2.0 tool.

Study	Risk by domain					Risk of bias
	Randomization	Deviations from intervention	Incomplete outcomes	Measurement of results	Selective reporting of outcome	
Kaiba et al. (2006)	?	+	+	+	+	?
Ikebe et al. (2007)	?	+	+	+	+	?
Kumamoto et al. (2010)	?	+	+	+	+	?

Judgement (risk of bias):

+ Low

? Moderate

Table 5. Certainty of evidence of the syntheses performed.

Certainty assessment							No. participants	Absolute effect	Overall certainty
No. Datasets	**Study design**	**Risk of bias**[a]	**Inconsistency**[b]	**Indirectness**	**Imprecision**[c]	**Other considerations**		**SMD (95% CI)**	
Stereognosis score immediately after palatal coverage (prosthesis)									
9	Interventional	Serious	Serious	Not serious	Serious	None	350	0.302 (-0.124, 0.728)	⊕◯◯◯ VERY LOW
Stereognosis score immediately after palatal coverage (prosthesis)									
4	Interventional	Serious[a]	Serious[b]	Not serious	Serious[c]	None	153	1.565 (0.899, 2.232)	⊕◯◯◯ VERY LOW

a Data from nonrandomized clinical trials (uncontrolled before-and-after studies) were synthesized.
b Lack of overlap between confidence intervals and index $I^2 > 75\%$.
c Insufficient number of evaluated subjects (<400).
Abbreviations: SMD, standardized mean difference; CD, confidence interval.

Fig. 1 PRISMA flowchart diagram of screening process.

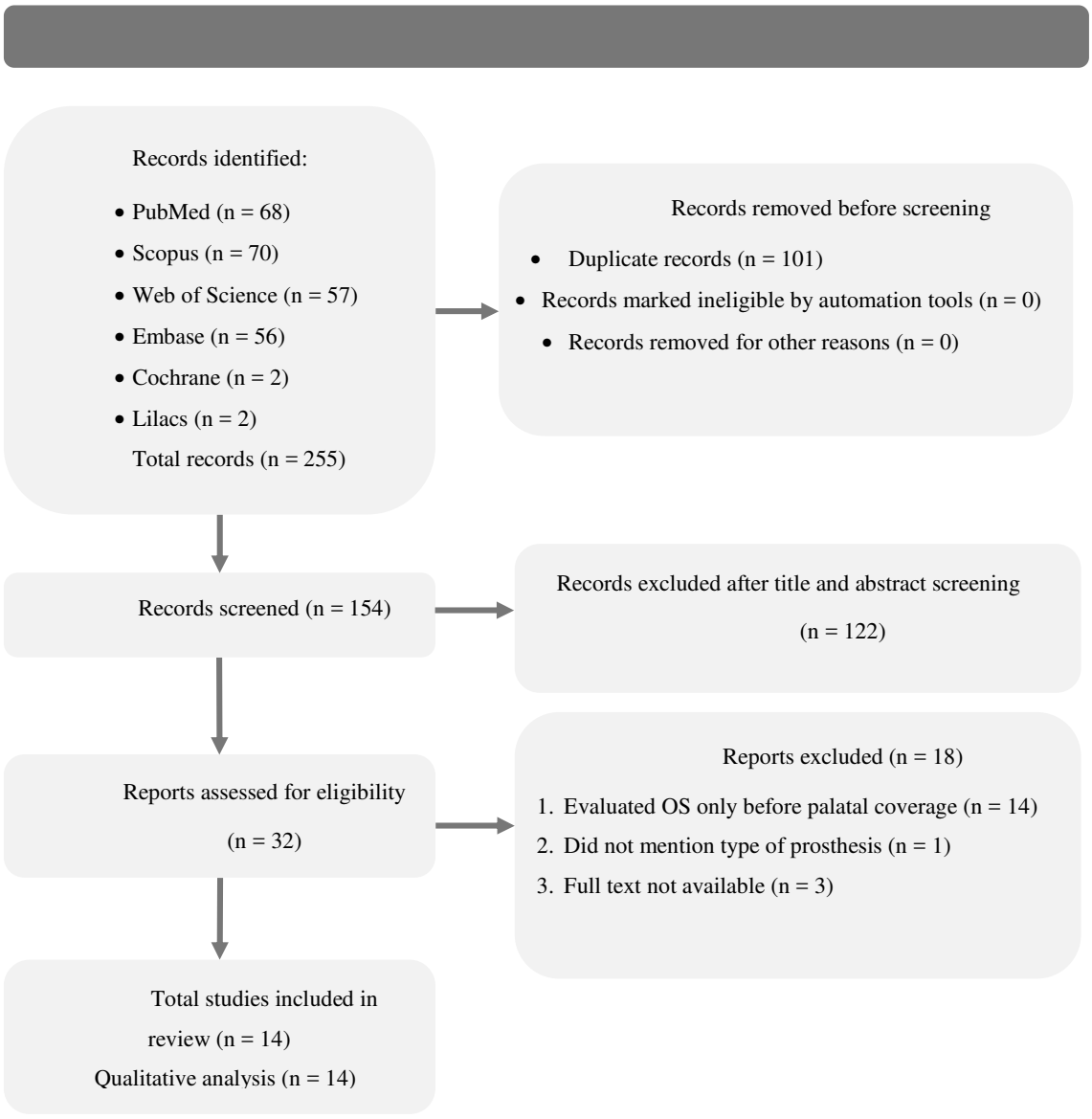


Fig. 2 Analysis of all studies included.

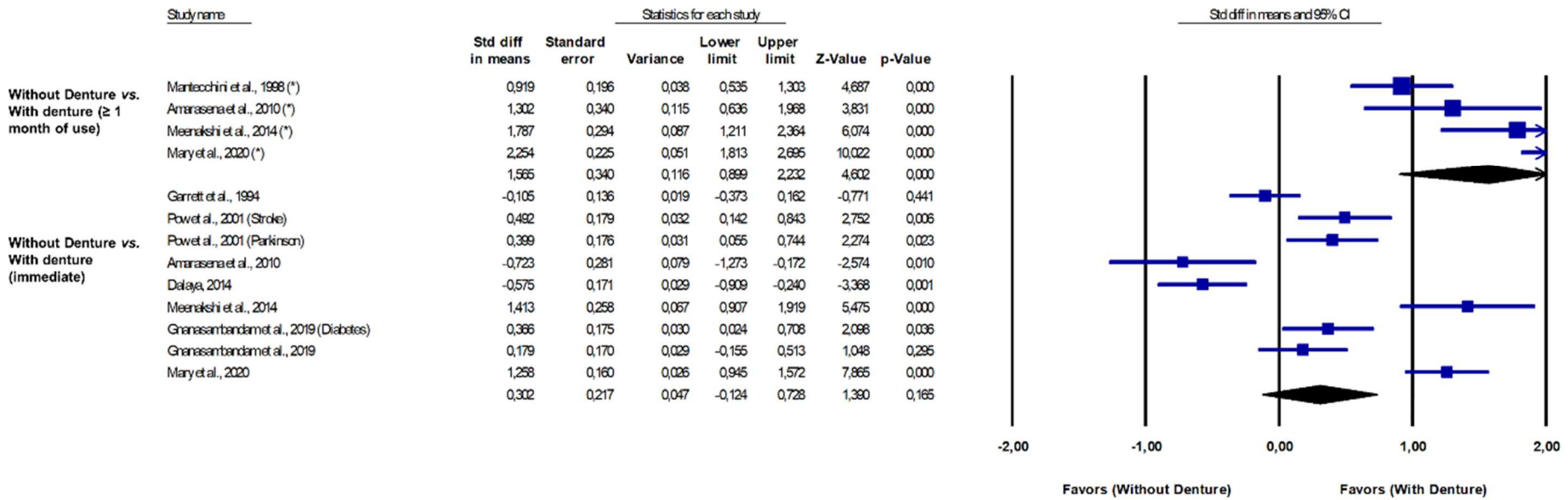
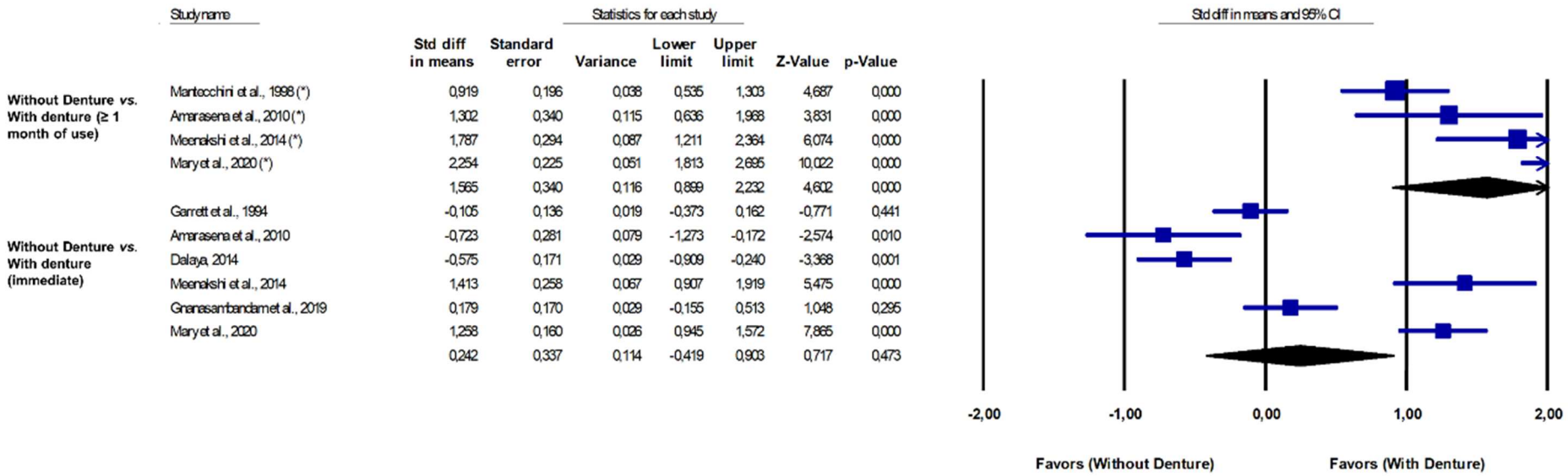


Fig. 3 Analysis excluding studies that examined patients with systemic disease.



2.2 Artigo: Potential effects of tongue lesions and palatal coverage on oral sensory functions*

Ana Paula Gadonski[1]

Talita Malini Carletti[1]

Mariana Marinho Davino de Medeiros[1]

Renata Cunha Matheus Rodrigues Garcia[1]

[1]Department of Prosthodontics and Periodontology

Piracicaba Dental School, University of Campinas, Piracicaba, Brazil.

Corresponding author:

Prof. Dr. Renata Cunha Matheus Rodrigues Garcia

Department of Prosthodontics and Periodontology

Piracicaba Dental School, University of Campinas

Avenida Limeira, 901, Bairro Areião, Piracicaba, SP, Brazil - 13414-903

Phone/Fax Number: +55 19 2106-5211

e-mail: regarcia@fop.unicamp.br

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Abstract

Aim: To evaluate whether tongue lesions and palatal coverage are disruptive to oral stereognosis (OS) and gustatory function. **Methods and Results:** Seventy participants (mean age, 30.71 ± 6.7 years) were divided into a tongue lesion (TL) group (experimental; $N = 35$) and a control (CON) group ($N = 35$). The TL group included participants with geographic tongue, fissured tongue, or hairy tongue. OS was evaluated with the oral stereognosis ability (OSA) test and the response time to the test was recorded in seconds. Gustatory function was assessed with exposure to flavored solutions. After completing the above tests, the participants received a palate-covering device, and then OS and gustatory function were immediately re-evaluated. The data were analyzed with Mann-Whitney and Wilcoxon tests (significant at $\alpha = 0.05$). OSA and gustatory function scores did not differ among the TL and CON groups with and without palatal coverage (all $p > 0.05$). After palatal coverage, the TL group took more time to perform the OSA test than the CON group ($p < 0.05$). **Conclusions:** Neither the presence of tongue lesions nor palatal coverage influenced OS or gustatory function. OSA test response times were longer for the TL group after they had palatal coverage.

Keywords: Stereognosis; glossitis; benign migratory; tongue fissured; tongue hairy; tongue diseases; palate.

Introduction

Structurally, the tongue is formed by a complex three-dimensional network of skeletal muscle fibers[1] and is covered by filiform, fungiform, circumvallate, and foliate papillae.[2] Filiform papillae are predominant on the dorsum of the tongue and perform strictly tactile and texture-sensing functions.[3,4] Meanwhile, fungiform papillae and circumvallate papillae, located primarily on anterior and posterior portions of the tongue respectively, transmit taste information.[2,5] Finally, foliate papillae, which mediate tactile and gustatory functions, are situated on the lateral portions of the tongue.[2,5] Thus, papillary structures on the tongue surface exert tactile and gustatory sensory functions that are important during chewing and swallowing.[6,7,8]

There are several types of tongue-surface lesions prevalent in adults, including geographic (a.k.a. benign migratory glossitis), fissured, and hairy tongue, that could, potentially, disrupt its functioning.[9] Geographic tongue presents as migratory filiform papilla-denuded areas of varying shape on the dorsum of the tongue.[10,11] Fissured tongue, which may co-occur with the benign migratory glossitis,[11] is characterized by furrows and fissures on the dorsal and lateral regions of the tongue.[11] Hairy tongue refers to abnormal overgrowth of filiform papillae in the anterior two-thirds of the tongue.[12] Although these lesions alter the surface of the tongue,[9-12] and can cause symptoms such as burning sensation and dysgeusia,[10,11] there is limited information regarding how they affect oral sensory function. Since the tactile receptors are majority present on the tongue surface,[3,4] it can be assumed that tongue lesions could affect oral sensory perception. However, there are no studies on this topic.

Oral stereognosis (OS) is an oral sensorial ability that can be used to identify shapes, sizes, and textures using only oral perception, without visual or auditory information.[13] OS involves higher-order neural processing and cognitive functions, including memory, identification, and language.[14] Stereognosis tests that measure OS have been used to predict the success of a dental prosthetic treatments[13,15-18] based on the precept that patients

with greater intraoral sensory perception should be better able to recognize roughness and denture-surface alterations and thus may express lower satisfaction with new prostheses.[17,18]

In dentate patients, OS is attributed in large part to proprioception via the periodontal ligaments.[18,19] As OS declines with tooth loss and advancing age,[14,17,20] other sensory receptors, such as those in the tongue and palate, may compensate.[17,19,21] Some authors have argued that palatal coverage resulting from complete dentures should not influence OS because oral sensory function relies primarily on lingual receptors[17,18,22] and that the complete upper denture can act as a rigid support for manipulating objects with the tongue.[17,22] Conversely, others have argued that covering the palate reduces OS[23,24] due to loss of involvement of palatal receptors in the detection of food particles[18] and creates an abrupt and irksome change in the intraoral environment.[23,25,26] The role of palatal receptors in OS remains to be clarified empirically.

Additionally, the influence of palatal coverage on gustatory function is still unclear. Wearing removable dentures have been reported to be related to taste changes after its installation.[27,28] In spite of exist an influence of age on taste perception, because of the deterioration of taste buds with over the years,[27] the presence of palatal coverage seems to be related to a decrease on gustatory function due to the gustatory receptors' overlay.[27,28]

Gustatory function is a taste perception that occurs due to chemicals mediators detected by cells from the taste buds[29] and the salivary flow rate of patients influences on this function.[30] The saliva is the main external fluid of gustatory receptors, protect taste buds and perform the transport of food taste chemical mediators.[31] Considering that taste receptors are located within papillae structures of the tongue,[29] it could be supposed that alterations on tongue papillae due to the presence of tongue lesions would affect the gustatory function of the patients. However, there are no studies concerning this topic.

The aims of this study were to evaluate whether benign tongue lesions and palate coverage influence OS as determined by the oral stereognosis ability (OSA) test, and gustatory function in dentate patients. We hypothesized that tongue lesions and/or palatal coverage would alter oral sensory functions.

Materials and methods

Study design

This clinical study assessed OS and gustatory function (dependent variables) in subjects with and without tongue lesions, with and without palatal coverage. After completing baseline OS, and gustatory function, the participants were fitted with a palatal device that covers the entire palate. OS and gustatory functions were re-assessed immediately after installation of the device.

Sample size was determined based on a pilot study of 15 dentate participants (7 with tongue lesions and 8 without) demonstrating OSA scores to be the factor of greatest variability. A single researcher performed all OSA tests. The mean OSA scores and standard deviations of subjects with and without tongue lesions were 9.29 ± 3.3 and 11 ± 1.51, respectively. The sample size calculation indicated that 32 volunteers per group would be sufficient to detect significant differences (power of 80%, significance level of 5%). To compensate for possible losses, 70 participants were enrolled.

Subjects

Students and staff at Piracicaba Dental School, University of Campinas, patients who sought dental treatment at our institution, and Piracicaba city residents were invited to participate in this study without gender or ethnic restrictions. The volunteer participants were divided into an experimental group with tongue lesions (TL group, $N = 35$) and a control group without any tongue lesions (CON group, $N = 35$).

The inclusion criteria for the TL group were: *(1)* age, 18–45 years old; *(2)* good general health, evaluated through questions of the volunteers' systemic condition; *(3)* complete permanent dentition (with or without third molars); and *(4)* benign tongue lesions, including geographic tongue, fissured tongue, and/or hairy tongue. The inclusion criteria for the CON group were the aforementioned criteria 1–3, but with the additional criteria of having no tongue lesions and having a normal salivary flow rate.[32] Because hairy tongue is found

mainly in smokers[33] and smokers may have reduced salivary flow, a salivary flow criterion was not implemented for the TL group.

Volunteers with malignant oral lesions, neuromuscular diseases, facial malformations, bruxism (with the presence of tongue indentation), or advanced periodontal disease were excluded by clinical exam. In addition, subjects using intraoral devices, removable prostheses, or fixed prostheses were excluded. All volunteers read and signed a consent form that was approved by the Ethics Committee for Piracicaba Dental School (protocol # 14772619.0.0000.5418). The study was registered in the Brazilian Registry of Clinical Trials (ReBEC; RBR- 5bs7dr).

Sociodemographic characteristics, including education level, were surveyed before conducting the baseline tests. Stimulated salivary flow rate was estimated by asking the volunteers to chew a 0.2-mm-thick piece of Parafilm (Parafilm M, Bemis Company, Inc., PA, USA) for 5 min.[34] Saliva was expectorated at 30-s intervals into a pre-weighed container. Salivary flow rate (mL/min) was calculated by subtracting the initial weight from the final weight of the container.[34]

Oral stereognosis

OS was assessed with the OSA test.[7] Six geometric shapes (square, rectangle, triangle, semicircle, circle, and ellipse), each measuring 8 mm × 8 mm × 2 mm, were made from raw carrot. Shapes were grouped into three pairs based on their similarity: circle and ellipse; triangle and semicircle; and square and rectangle.[7] The test was performed by a single researcher, with the volunteer seated in a dental chair with their eyes closed. Each geometric shape was placed alone in a random positioned on the mid-dorsal surface of the volunteer's tongue.[7] The participant was then instructed to move the object between the tongue and the palate, without touching the teeth and without a time limit, with the aim of identifying the object's shape.[35] Subsequently, the participant was shown a chart of illustrations of eight shapes,[19,36] including the six included in the test as well as two others (hexagon and addition sign),[37] and instructed to point to the shape corresponding to the

piece in their mouth.[7] The attending researcher recorded the answers and the time in seconds required to identify each shape. A 3-point scale was used to classify answers as correct (2 points), partially correct (incorrect but shape in the same group as given answer; 1 point), and incorrect (0 points).[7] Thus, scores ranged from 0 to 12 points, with higher scores indicating better OS.

Gustatory function

Four solutions representing sweet, salty, sour, and bitter flavors[3,4] were used as stimuli to evaluate gustatory function. The solutions were flavored (1 mol/L distilled water) with sucrose (for sweet taste), sodium chloride (salty), citric acid (sour), and quinine hydrochloride (bitter taste), respectively.[4] The solutions were diluted one day prior to the test and were stored at refrigerator.[28] Each solution was kept at room temperature before tests.[26] The participants were instructed not to eat or drink 1 h before the procedure. The ends of 8-cm-long filter paper strips were soaked in single solutions until it was impregnated and then applied to the mid-dorsal surface of the tongue for approximately 5 s.[3,4] A different filter paper strip was used for each of the solutions.[3,4] The order of flavor exposure was random except that the bitter taste was always the last to be tested because it can alter the perception of other flavors.[27,38] Volunteers were instructed to identify the basic flavor of the tape, and the researcher recorded 1 point for each correctly identified flavor. Total scores ranged from 0 to 4 points, with higher scores indicating better gustatory function.[3]

Palatal coverage

The palate was covered with the installation of an acrylic device. Impressions of all volunteers' upper dental arches were obtained with alginate (Hydrogum 5, Zhermack SpA, Badia Polesine, Italy), and master casts were processed with type III dental stone (Herodent, Vigodent S/A Indústria e Comércio Ltda, Rio de Janeiro, Brazil). Interproximal retention clasps made of 0.7 mm orthodontic steel wire (Dental Morelli Ltda, Sorocaba, São Paulo, Brazil) were positioned in the interproximal region between the upper second pre-molars and

first molars, with no occlusal interference. The devices were finished by adding a self-curing acrylic resin (Vipi Flash Incolor, Vipi Produtos Odontológico, Pirassununga, São Paulo, Brazil), ensuring a total palatal coverage. The devices were limited anteriorly by the lingual surface of the upper teeth and limited posteriorly by the hard and soft palate junction.[6] To ensure a similar thickness of all palatal devices, a digital caliper (Digital Coolant Proof Absolute IP-67 Caliper, Mitutoyo Sul Americana Ltda, Suzano, São Paulo, Brazil) was used to measure the palatal device thickness in four regions: anterior, central, and lateral (left and right, in the region of first molars). After finishing and polishing, a final thickness of ~1.2 mm was obtained for all palatal devices,[6,35] consistent with the typical thickness of removable upper dentures.[6] The palatal device was installed and adjusted to make no contact with the opposing teeth at the maximum intercuspal position.[17,23]

Statistical analysis

The dependent variables were tested for normality with the Kolmogorov-Smirnov test. Considering the non-normal distribution of the data, even after data transformation, non-parametrical tests were used for statistical analysis. The Mann-Whitney test was used to compare OS and gustatory function values according between the TL and CON groups. The Wilcoxon test was used to compare OS and gustatory function results before versus after palatal coverage. The data of salivary flow rate of the subjects had normal distribution and were evaluated with the independent t-test. All analyses were performed with a significance level of 5% (SPSS for Windows, version 20.0, IBM).

Results

The participants' sociodemographic characteristics, including age distribution, gender, tongue lesion diagnosis and educational level are presented in Table 1. The TL group (years, mean ± SD, 33 ± 7) included more men than women and a majority of the TL group participants completed high school. The CON group (years, mean ± SD, 29 ± 5) included more women than men and a majority of the CON group participants had at least some

undergraduate education. Fissured tongue was the most prevalent lesion diagnosis (61,8%), being observed in more than half of the TL group participants. The salivary flow rate did not differ between groups (p = 0.916).

No differences were found in median OSA and gustatory function scores between the TL and CON groups at either evaluation timepoint, nor between the before and the after palatal coverage evaluations within each group (Table 2). Compared to their baseline pre-palatal covering device installation OSA test results, participants with tongue lesions took longer ($p < 0.05$) to recognize shapes orally in the OSA test after being fitted with a palate covering device (Table 3).

Discussion

OS is performed by the combination of motor activity of the tongue, through the manipulation of objects within the mouth,[13,17,22] and the acting of tactile receptors present on the tongue' surface.[3,4] Therefore, it could be hypnotized that alterations on the dorsum of the tongue would affect the oral sensory perception, however the prediction that tongue lesions would influence OS was not confirmed. This non-influence might be due to the differentiated locations of filiform and foliate papillae, both of which mediate tactile sensory functions. Geographic, fissured, or hairy tongue lesions affect mostly the dorsum of the tongue where filiform papillae are found, leaving foliate papillae along the lateral edges of tongue unaltered.[2,5] The sensorial function of intact foliate papillae could thus continue to mediate OS in the presence of a palate-covering apparatus. Gustatory function was not found to be influenced by geographic, fissured, or hairy tongues, consistent with the view that taste stimulation occurs mainly by way of receptors located in circumvallate papillae, which are found mostly on the back of the tongue.[5]

Our results indicating that palatal coverage did not alter OS, even in patients with tongue lesions, corroborate several studies demonstrating a lack of influence of palatal coverage on OS[15-17,24,,36,39] and further affirm that oral tactile information is gained primarily from sensory receptors in the tongue.[24,25,40] On the other hand, these findings contrast with

those of studies[18,23,24] showing effects of palatal coverage on tactile feedback via lingual receptors.[18,23,24] Methodological differences between studies may explain this difference. While Kaiba et al.'s[23] study participants wore a palatal device for 7 days before testing, we performed OS tests immediately after device installation, thus allowing more opportunity for adaptation. In addition, whereas our study was conducted with dentate participants, Ikbal et al.[24] studied edentulous elderly people who had been using complete dentures and/or implant-supported dentures for varying periods of time. Finally, Gnanasambandam et al.[18] evaluated the effects of palatal coverage on OS in a clinical sample of diabetic patients.

Flavor chemicals dissolved in saliva are detected by gustatory receptors found throughout the oral cavity.[40] Patients often complain about changes in taste perception after installation of complete dentures, because the food might not dissipate in the mouth as in the absence of palatal coverage.[41] Consequently the contact of the chemicals with the gustatory receptors would be affected and a decrease on gustatory function may be noticed.[41] However, the gustatory function of our participants was also not influenced by palatal coverage in our study, consistent with Kapur et al.'s[42] report. The sparsity of gustatory receptors on the palate[42] may explain the ability of participants to taste effectively without their involvement. Though they are most concentrated on the tongue, gustatory receptors are found throughout the oral cavity,[40] including at low densities in the oropharynx,[40] which could aid in gustatory function.

Interestingly, TL group participants took longer to recognize the shapes rectangle, triangle and circle after palatal coverage. Shape identification may take longer in these subjects due to participants with tongue lesions moving the stimuli away from the dorsum of the tongue, where lesions mainly occur,[2,5] to intact areas of the tongue on the lateral and anterior portions of the tongue. Distinct from prior studies wherein participants were free to move objects throughout the oral cavity,[7,37,43,44] we instructed the participants of this study to keep the stimulus objects between the tongue and palate to avoid dental proprioception. These methodological differences together with the sudden change in the oral environment

induced by palatal coverage[43] may have contributed to the increased response times of our TL group participants at the post-palatal coverage timepoint.

Although shapes with corners have been reported previously to be more easily identified than shapes without corners,[7,37,43,44] our study participants took longer to recognize triangles and rectangles than to recognize circles. The differently-sized sides of a rectangle could have slowed its identification. Meanwhile, it could be that the relatively small tongue-contacting areas of triangles[7] extended the time needed to identify them.

It is important to emphasize that normal salivary flow rate was established as an inclusion criteria for the control group, due to its influence on taste perception.[30,31,45] Considering that smokers present reduced salivary flow[32] and are the most common patients to present hairy tongue, it could be expected that this condition would influence results and figure as a bias. However, such assumption was not confirmed, probably due the fact that only three volunteers presented hairy tongue and were smokers. Furthermore, no difference on salivary flow were found between TL and CON group, what may also aid to support our finding.

This study had two noteworthy limitations. Firstly, it was a short-term study involving participants with a recently installed palatal coverage device. Secondly, we included only the three most prevalent benign tongue lesion types. Further studies investigating the influence of other types of tongue lesions on OS and gustatory function, and with the inclusion of long-term denture wearers and longer follow-up periods are encouraged.

Conclusions

Tongue lesions and palatal coverage do not influence dentate patients' OS ability, as evidenced by OSA scores, or their gustatory function. Nonetheless, after palatal coverage, participants with tongue lesions presented longer OSA test response times.

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Conflict of interest

The authors have no conflicts of interest.

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Table 1 Characteristics of the study groups

Characteristic	**Experimental (*n* = 35)**	**Control (*n* = 35)**	***P*-value**
Age (years, mean ± SD)	33 ± 7	29 ± 5	0.010
Gender [n (%)]			
Male	20 (57.1)	15 (42.9)	0.232
Female	15 (42.9)	20 (57.1)	
Tongue lesions [n (%)]			
Migratory glossitis	7 (20.6)	-	
Fissured tongue	21 (61.8)	-	
Hairy tongue	3 (8.8)	-	
Fissured and geographic tongue	3 (8.0)	-	
Educational level [subjects (%)]			
Middle school (1-9 y)	4 (11.4)	2 (5.7)	
High school (10-12 y)	17 (48.6)	2 (5.7)	
Graduate/undergraduate (13y or more)	14 (40.0)	31 (88.6)	< 0.001
Salivary flow rate (mL/min, mean ± SD)	1.93 ± 0.10	1.85 ± 0.10	0.916
Smokers	3 (8.8)	-	

Table 2. Oral stereognosis scores and gustatory function before and after palatal coverage for the studied groups

	Oral stereognosis scores		**Gustatory function**	
Groups	Before PC	After PC	Before PC	After PC
Experimental	8 (6-10) Aa	9 (6-10) Aa	4(3-4) Aa	4(3-4) Aa
Control	9 (8-10) Aa	10 (8-11) Aa	4(3-4) Aa	4(3-4) Aa

PC: palatal coverage.

Values represent median (percentile 25-75).

Values followed by distinct uppercase letters indicate differences ($P < 0.05$) between groups (Mann-Whitney test).

Values followed by distinct lowercase letters indicate differences ($P < 0.05$) between before and after palatal coverage (Wilcoxon test).

Table 3. Response times (seconds) for each form of the oral stereognosis test, before and after palatal coverage for the studied groups

Shaped forms	**Response time (seconds)**			
	Before palatal coverage		After palatal coverage	
	Experimental	Control	Experimental	Control
Rectangle	9.60 (4.78-32.96) Aa	6.34 (3.76-29.70) Aa	11,71 (7,45-40,33) Aa	5,57 (3,60-20,05) Ba
Triangle	5.83 (3.61-11.99) Aa	5.63 (3.21-28.76) Aa	8,11 (4,05-20,28) Aa	4,65 (2,43-11,98) Ba
Square	8.59 (5.36-30.40) Aa	6.81 (3.65-24.27) Aa	7,52 (6,48-25,41) Aa	5,37 (4,60-18,00) Aa
Circle	9.35 (6.00-29.57) Aa	8,07 (4,47-31,39) Aa	9,98 (5,67-39,21) Aa	6,37 (3,93-27,30) Ba
Semi-circle	11.34 (5.49-31.48) Aa	7.26 (4.91-23.68) Aa	9,03 (5,38-28,50) Aa	7,80 (5,11-22,05) Aa
Ellipse	11.58 (7.78-35.35) Aa	8.52 (4.99-24.71) Aa	11,26 (7,41-46,60) Aa	8,90 (6,29-33,96) Aa
Total	62.36 (47.90-141.74) Aa	44.79 (38.32-125.78) Aa	61,47 (48,04-185,95) Aa	45,59 (34,58-98,05) Ba

Values represent median (percentile 25-75).

Values followed by distinct uppercase letters indicate differences ($P < 0.05$) between groups (Mann-Whitney test).

Values followed by distinct lowercase letters differences ($P < 0.05$) between before and after palatal coverage (Wilcoxon test).

Author Contribution Statement

Ana Paula Gadonski

Contributed to the design, acquisition data, analysis and interpretation of data, and drafting the manuscript.

Talita Malini Carletti and Mariana Marinho Davino de Medeiros

Contributed substantially to the data collection and analysis and interpretation of data.

Renata Cunha Matheus Rodrigues Garcia

Contributed to the conception and design, analysis and interpretation of data, drafting the manuscript and given the final approval of the version to be published.

3 DISCUSSÃO

O presente estudo avaliou por meio de revisão sistemática da literatura a possível influência do recobrimento do palato, por meio do uso de próteses ou dispositivos palatinos, sobre a EO, e foi observado que, apesar de não haver alteração na percepção sensorial oral imediatamente após o recobrimento palatino, a EO dos pacientes melhorou após 1 mês ou mais da instalação de próteses ou dispositivos palatinos. Além da revisão sistemática, também foi realizado um estudo clínico avaliando a influência de alterações de normalidade de língua e recobrimento palatino sobre a EO e função gustativa de indivíduos dentados, demonstrando que não houve diferença entre os grupos experimental e controle frente ao recobrimento palatino, mas que após a instalação do dispositivo palatino os indivíduos com alterações de normalidade de língua levaram mais tempo para realizar o teste de EO.

A literatura mostra que existem receptores táteis em toda a cavidade oral (Suter *et al*., 2021), mas a atuação dos receptores palatinos sobre a EO ainda é controversa. Nesse contexto, esperava-se que o recobrimento palatino pudesse afetar a percepção sensorial oral dos pacientes. Contrário à essa expectativa, não houve diferença para a EO imediatamente após a instalação de próteses ou dispositivos palatinos, tanto na revisão sistemática quanto no estudo clínico realizados. Esse resultado provavelmente se deve ao fato de que os receptores táteis linguais atuam de forma predominante sobre a EO (Kapur *et al*., 1967; Ikbal *et al*., 2014; Steele *et al*., 2017). Além disso, sabe-se que a EO depende primordialmente da função motora lingual (Bangcuyo *et al*., 2017), assim o recobrimento palatino é utilizado como um anteparo rígido para que a língua realize a identificação dos objetos (Dalaya, 2014; Kilic *et al*., 2019). No entanto, observou-se na revisão sistemática que após um ou mais meses após a instalação de próteses, houve melhora da percepção sensorial oral dos indivíduos, o que pode ser explicado pela capacidade de adaptação do sistema estomatognático ao tratamento reabilitador (Kaiba *et al*., 2006; Mary *et al*., 2020). Estudos incluídos na revisão mostraram ainda que, quando comparado ao estado edentado, usuários de próteses totais apresentam melhor EO na presença dessas (Meenakshi *et al*., 2014; Bhandari *et al*., 2010; Mantechinni *et al*., 2017; Mary *et al*., 2020), indicando que um tratamento reabilitador adequado é de grande importância no aprimoramento da percepção sensorial oral após o recobrimento palatino.

Em adição, a influência do recobrimento palatino, por meio de dispositivos palatinos, sobre a função gustativa foi analisada no estudo clínico realizado. Como esperado, a função gustativa não foi alterada após o recobrimento palatino, uma vez que os receptores gustativos estão em sua maioria concentrados na superfície lingual (Kapur *et al*., 1967), bem como em outros locais da cavidade oral (Suter *et al*., 2021), permitindo o desempenho adequado da função gustativa mesmo na presença do recobrimento palatino.

As alterações de normalidade de língua acarretam em mudanças nas estruturas papilares, essas responsáveis pelas funções tátil e gustativa (Snyder & Bartoshuk *et al*., 2016; Suter *et al*., 2017; Bangi *et al*., 2019). Desse modo, esperava-se que indivíduos com língua geográfica, fissurada ou pilosa apresentassem redução nas funções sensoriais orais. Entretanto, observou-se que as alterações na superfície lingual decorrentes das alterações de normalidade de língua não influenciaram a EO e função gustativa. Esse fato provavelmente está relacionado à diferença que existe entre as áreas linguais afetadas pelas alterações e as áreas que desempenham as funções sensoriais orais. Além disso, notou-se que indivíduos com alterações de normalidade de língua precisaram de maior tempo para concluir o teste de EO, o que pode ter ocorrido pelo fato de que esses pacientes necessitam movimentar mais as formas geométricas na superfície da língua.

Em adição, por meio da revisão sistemática realizada evidenciou-se que estudos já relataram uma possível relação da EO com doenças sistêmicas que apresentam manifestação na cavidade oral (Bakke *et al*., 2011; Gnanasamdandam *et al*., 2019). A percepção sensorial oral é afetada por doenças neurodegenerativas como a doença de Parkinson, e a diabete. A doença de Parkinson é conhecida por acometer a coordenação muscular dos indivíduos, afetando, no caso da face, o movimento mandibular e lingual (Bakke *et al*., 2011). Uma vez que a EO é dependente da movimentação lingual para identificação de objetos na cavidade oral (Bakke *et al*., 2011), pode-se supor que a doença de Parkinson em níveis avançados afeta negativamente a mesma. No entanto, não observou-se diferença na EO de indivíduos portadores da doença de Parkinson, o que ser atribuído ao controle dos movimentos musculares por medicamentos, ou mesmo o estágio de progressão da doença. Do mesmo modo, sabe-se que a diabete acarreta lesões e processos inflamatórios na cavidade oral, além da chamada neuropatia diabética, responsável por alterar a sensibilidade das extremidades corporais, como a língua (Gnanasamdandam *et al*., 2019). Contrariando o esperado, verificou-se que a diabete não reduziu a percepção sensorial oral dos indivíduos. Esse resultado pode ser atribuído à adequada reabilitação dos pacientes, permitindo que o sistema estomatognático exerça suas funções normalmente.

Por fim, apesar da percepção sensorial oral ser de grande importância para a adequada função do sistema estomatognático, e ser importante que essa seja reestabelecida após a reabilitação oral dos pacientes, indivíduos com maior percepção sensorial oral podem apresentar maiores complicações e dificuldade de adaptação no período pós-instalação de próteses (Gnanasamdandam *et al*., 2019). Desse modo, cabe ao cirurgião-dentista esclarecer que a adaptação é um processo gradativo que requer tempo e paciência. Em que pese os resultados apresentados nessa dissertação, os dados precisam ser analisados com cautela uma vez que no estudo clínico foram avaliadas apenas três alterações de normalidade de língua, em voluntários adultos, e o recobrimento palatino foi avaliado em um curto espaço de

tempo (imediatamente após a instalação dos dispositivos de recobrimento palatino). Assim, futuros estudos são necessários para aumentar o nível de evidência da influência do recobrimento palatino sobre as funções sensoriais orais, com a avaliação da EO em maiores períodos de tempo em indivíduos desdentados e usuários de próteses.

4 CONCLUSÃO

Diante dos resultados obtidos nos artigos apresentados neste trabalho, concluiu-se que o recobrimento palatino não influencia a EO e função gustativa. No entanto, a percepção sensorial oral melhora após o período de adaptação dos indivíduos à próteses ou dispositivos palatinos.

As alterações de normalidade de língua não estão relacionadas à mudanças nas funções sensoriais orais. Entretanto, indivíduos com alterações de normalidade de língua, imediatamente após a instalação de dispositivos palatinos, necessitam maior tempo para a identificação de formas no teste de EO.

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ANEXOS

Anexo 1 – Parecer de aprovação do Comitê de Ética em Pesquisa da Faculdade de Odontologia de Piracicaba

UNICAMP - FACULDADE DE ODONTOLOGIA DE PIRACICABA DA

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Estereognose oral em indivíduos com alteração de normalidade da língua.
Pesquisador: Renata Cunha Matheus Rodrigues Garcia
Área Temática:
Versão: 2
CAAE: 14772619.0.0000.5418
Instituição Proponente: Faculdade de Odontologia de Piracicaba - Unicamp
Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 3.426.135

Apresentação do Projeto:
Transcrição editada do conteúdo do registro do protocolo e dos arquivos anexados à Plataforma Brasil Delineamento da pesquisa: Trata-se de um estudo clínico observacional transversal para avaliação da função sensorial oral e função gustativa (variáveis dependentes) em pacientes dentados com presença de alterações de normalidade de língua, recobrimento ou não do palato e diferentes níveis educacionais (variáveis independentes). A função sensorial oral será avaliada por meio de teste de EO, como proposto por Hirano et al. (2004), e será realizada com e sem o recobrimento do palato por meio de dispositivos palatinos. A função gustativa será avaliada por meio do uso de soluções representativas dos quatro sabores básicos (doce, salgado, azedo e amargo). Em acréscimo, o fluxo salivar dos voluntários será avaliado por meio de teste de estimulação salivar, uma vez que a quantidade de saliva parece influenciar a função gustativa. Serão selecionados 30 participantes, adultos dentados entre 18 a 45 anos de idade.
Pendência 01 (ATENDIDA EM 17/06/2019): Os pesquisadores esclareceram que "O estudo piloto será realizado com 10 participantes e estima-se, com base na literatura, que serão necessários para a pesquisa um total de 30 voluntários. O arquivo 2Projeto foi alterado como solicitado e grifado em amarelo. O texto foi igualmente ajustado na PB".
Pendência 02 (ATENDIDA EM 17/06/2019): Os pesquisadores esclareceram que "Não haverá distinção entre os sexos ou divisão de um número exato de gênero para os grupos da pesquisa. O arquivo 2Projeto foi alterado em Seleção de Voluntários e grifado como solicitado. O texto foi

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Outros	61Anexo.pdf	17/06/2019 16:32:12	Garcia	Aceito
Declaração de Instituição e Infraestrutura	54AltInfra.pdf	17/06/2019 16:31:42	Renata Cunha Matheus Rodrigues Garcia	Aceito
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Declaração de Instituição e Infraestrutura	52DeclaraInstituicao.pdf	30/05/2019 14:15:05	Renata Cunha Matheus Rodrigues Garcia	Aceito
Declaração de Pesquisadores	51DeclaraPesquisadores.pdf	30/05/2019 14:14:42	Renata Cunha Matheus Rodrigues Garcia	Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

PIRACICABA, 29 de Junho de 2019

Assinado por:
Fernanda Miori Pascon
(Coordenador(a))

Anexo 2 - Protocolo de submissão ao periódico Journal do Prosthetic Dentistry

Ms. Ref. No.: JPD-D-22-00663
Title: Palatal coverage and oral stereognosis: a systematic review and meta-analysis
The Journal of Prosthetic Dentistry

Dear Professor Renata Cunha Matheus Rodrigues Garcia,

Your submission "Palatal coverage and oral stereognosis: a systematic review and meta-analysis" has been assigned manuscript number JPD-D-22-00663.

To track the status of your paper, please do the following:

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Kind regards,

Justin Brown-Ramsey, M.A.
Editorial Office
The Journal of Prosthetic Dentistry

Anexo 3 – Protocolo de submissão ao periódico Special Care in Dentistry

Dear Renata Garcia,

Your manuscript entitled "Potential effects of tongue lesions and palatal coverage on oral sensory functions" has been successfully submitted online and is being delivered to the Editorial Office of *Special Care in Dentistry* for consideration.

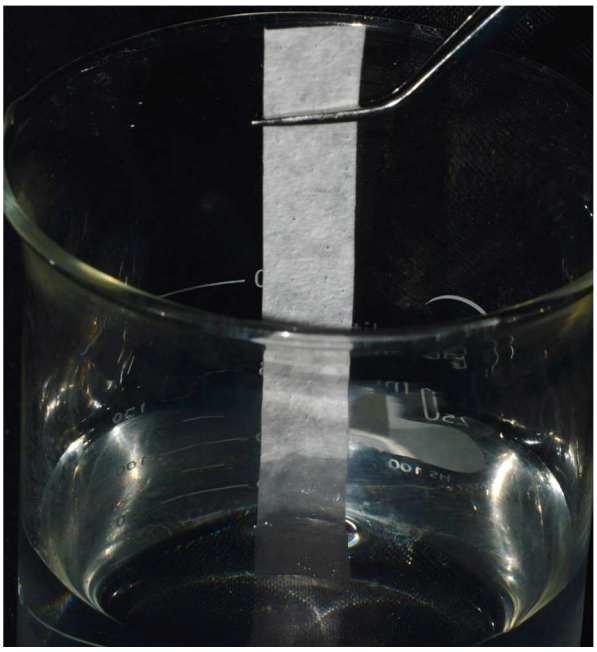
You will receive a follow-up email with further instructions from our electronic editorial office platform, ScholarOne Manuscripts, typically within one business day. That message will confirm that the Editorial Office has received your submission and will provide your Manuscript ID.

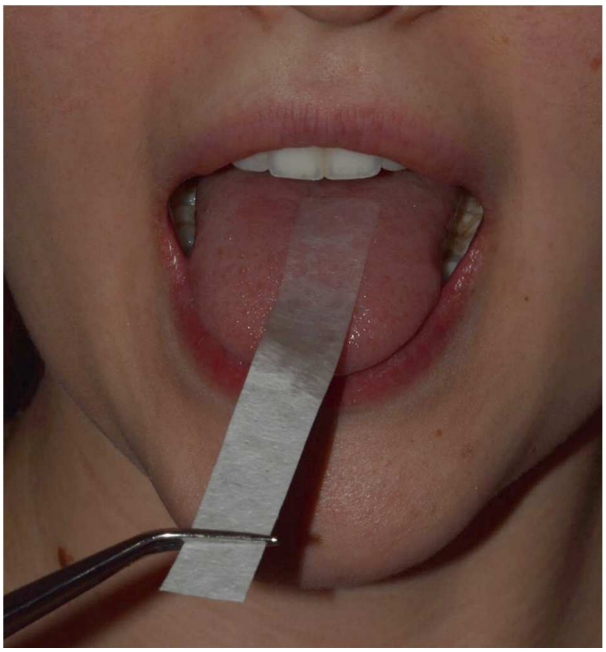
Thank you for submitting your manuscript to *Special Care in Dentistry*

Sincerely,
The Editorial Staff at Special Care in Dentistry

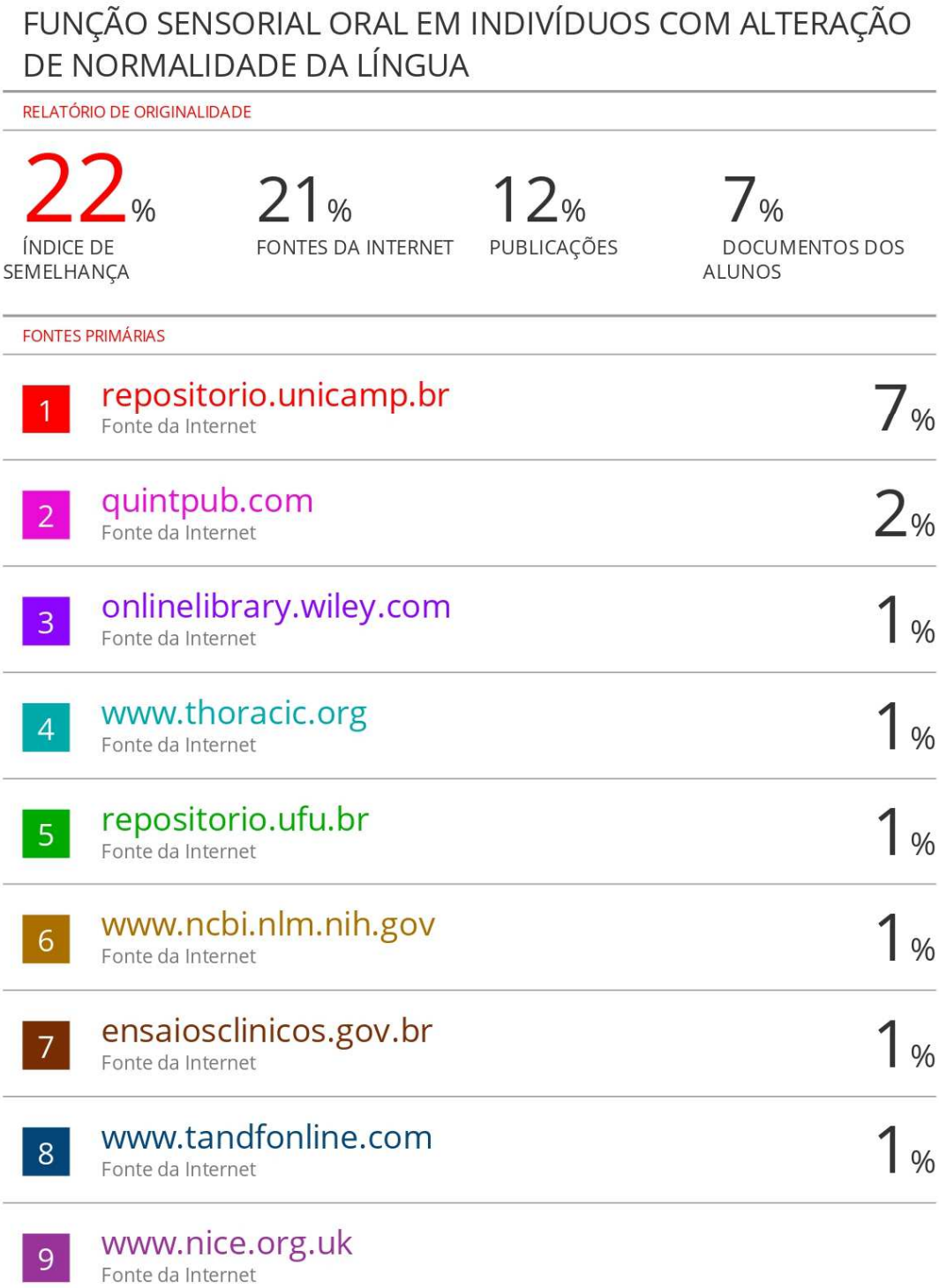
Anexo 4 – Formas geométricas utilizadas no teste de EO

Anexo 5 – Teste da função gustativa





Anexo 6 – Relatório de similaridade



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