



UNIVERSIDADE FEDERAL DE SANTA CATARINA
CENTRO DE CIÊNCIAS DA SAÚDE
PROGRAMA DE PÓS-GRADUAÇÃO EM ODONTOLOGIA

Adriana Pinto Bezerra

Efeito da reabilitação com implantes sobre a nutrição: revisão sistemática e meta-análise

Florianópolis

2020

Adriana Pinto Bezerra

Efeito da reabilitação com implantes sobre a nutrição: revisão sistemática e meta-análise

Dissertação submetida ao Programa de Pós-graduação em Odontologia da Universidade Federal de Santa Catarina para a obtenção do título de mestre em Odontologia.

Orientador: Profa. Dra. Thais Marques Simek Vega Gonçalves

Florianópolis

2020

Ficha de identificação da obra

Bezerra, Adriana

Efeito da reabilitação com implantes sobre a nutrição: :
revisão sistemática e meta-análise / Adriana Bezerra ;
orientadora, Thais Marques Simek Vega Gonçalves, 2020.
89 p.

Dissertação (mestrado) - Universidade Federal de Santa
Catarina, Centro de Ciências da Saúde, Programa de Pós
Graduação em Odontologia, Florianópolis, 2020.

Inclui referências.

1. Odontologia. 2. Prótese dentária suportada por
implantes. 3. Nutrição. 4. Revisão sistemática. 5. Meta
análise. I. Marques Simek Vega Gonçalves, Thais . II.
Universidade Federal de Santa Catarina. Programa de Pós
Graduação em Odontologia. III. Título.

Adriana Pinto Bezerra

Efeito da reabilitação com implantes sobre a nutrição: revisão sistemática e meta-análise

O presente trabalho em nível de mestrado foi avaliado e aprovado por banca examinadora composta pelos seguintes membros:

Profa. Thais Marques Simek Vega Gonçalves, Dra.
Universidade Federal de Santa Catarina

Prof. Luciano José Pereira, Dr.
Universidade Federal de Lavras

Prof. Maurício Malheiros Badaró, Dr.
Universidade Federal de Santa Catarina

Certificamos que esta é a **versão original e final** do trabalho de conclusão que foi julgado adequado para obtenção do título de mestre em Odontologia.

Profa. Dra. Elena Riet Corrêa Rivero
Coordenação do Programa de Pós-Graduação

Profa. Dra. Thais Marques Simek Vega Gonçalves
Orientadora

Florianópolis, 2020.

Este trabalho é dedicado ao meu marido Luiz, aos meus pais Pedro e Dilma e meu irmão Pedro Henrique.

AGRADECIMENTOS

Aos meus pais e irmão, **Pedro, Dilma e Pedro Henrique**. O apoio incondicional de vocês foi essencial para toda minha formação pessoal e acadêmica. Vocês são meus principais exemplos de vida, espero que vocês sintam tanto orgulho de mim quanto sinto de vocês. Meu muito obrigada.

Ao meu marido **Luiz Carlos**, meu companheiro de vida e de jornada acadêmica. Você me acompanhou durante todo mestrado, partilhando experiências, me ensinando, aconselhando e, algumas vezes, consolando. Não sei como teriam sido esses dois anos sem você do meu lado.

Aos meus sogros, **Luiz Carlos e Lianne**, por serem como segundos pais pra mim, me acolhendo como filha. Agradeço toda preocupação, apoio, suporte e amor de vocês.

Às amigas, **Amanda Lima, Larissa Lustosa, Marcella Auad, Gabriela Lima, Karollina Salgado, Marta Martins, Karina Salgado e Fernanda Lima**, pela amizade incondicional e que se fez presente todos os dias, mesmo com muitos quilômetros nos separando. Obrigada por serem ouvido e acalento em todos os momentos.

A todos os **amigos e familiares**, que sempre torceram por mim. O amor e apoio de vocês foi fundamental.

A minha orientadora, **Profa. Dra. Thais Marques Simek Vega Gonçalves**, por todo conhecimento compartilhado, me ajudando a traçar meus primeiros passos como pesquisadora. Obrigada por todos os conselhos, ensinamentos, disponibilidade e paciência. Sua contribuição e parceria foram essenciais para a construção desse e de todos os trabalhos desenvolvidos nesses dois anos de convivência. Muito obrigada.

À minha amiga e segunda revisora desse trabalho, **Lorena Tavares Gama**. Pela contribuição imprescindível para o desenvolvimento desse trabalho e por todo o auxílio e amizade dentro e fora do mestrado. Paraenses sempre se encontram e a nossa parceria foi essencial e muito importante pra mim.

Às minhas amigas de pós-graduação, **Tarla Thaynara Oliveira dos Santos e Franciele Quiquo Santiago Floriani e Laís Duarte**, pela amizade e acolhimento desde o primeiro momento dessa paraense em terras catarinenses. Um obrigada especial à amiga **Gabriela Panca Sabatini** pelo companheirismo, risadas diárias e desabafos compartilhados.

Às Profas. Dras. **Analucia Gebler Philippi e Karla Teixeira Nunes**, e aos Profs. Drs., **Maurício Malheiros Badaró e Luis André Mendonça Mezzomo**, pela amizade e por todas

as oportunidades, incentivos, ensinamentos e auxílio nas atividades do projeto, assim como nas clínicas diárias.

A Coordenadora do Programa de Pós-Graduação em Odontologia, Prof. Dra. **Elena Riet Correa Rivero**.

À secretária do Programa de Pós-Graduação em Odontologia, **Débora dos P. Rodrigues Coelho**, por todo suporte e disponibilidade.

A todos os **docentes do Programa de Pós-graduação em Odontologia** da Universidade Federal de Santa Catarina, pela contribuição imprescindível para minha formação acadêmica.

A todos os **servidores e funcionários** da Universidade Federal de Santa Catarina, por todo auxílio, disponibilidade e suporte.

À **CAPES, Coordenação de Aperfeiçoamento de Pessoal de Nível Superior**, pela bolsa de estudo concedida a mim durante esse período de estudo.

APRESENTAÇÃO

Esta revisão sistemática foi escrita originalmente sob a forma de artigo científico na língua inglesa, com o objetivo de ser submetido ao periódico *Clinical Nutrition* em parceria com o pesquisador da Universidade de Utrecht, Prof. Dr. Andries van der Bilt; do Prof. Dr. Luciano José Pereira, pesquisador da Universidade Federal de Lavras; das pesquisadoras da Universidade Estadual de Campinas (UNICAMP), Profa. Dra. Renata Cunha Matheus Rodrigues Garcia e Lorena Tavares Gama; juntamente com a professora e pesquisadora da Universidade de Clermont (França), Profa. Dra. Marie Agnes Peyron.

RESUMO

Objetivos: Revisar sistematicamente a literatura a fim de avaliar o efeito do uso de próteses sobre implantes sobre o estado nutricional (concentração sérica dos nutrientes, medidas antropométricas, ingestão nutricional, questionários sobre dieta). E, também, acessar uma possível relação de causa-efeito entre a ingestão nutricional e a função mastigatória desses pacientes. **Material e métodos:** A busca bibliográfica incluiu 6 bases de dados (última atualização em julho de 2020) e 3 bases de literatura cinzenta, sem restrições de idioma, tempo de publicação ou tempo de acompanhamento. Apenas estudos avaliando simultaneamente o estado nutricional e a função mastigatória foram incluídos. O risco de viés e a qualidade dos estudos foram avaliados e os dados nutricionais foram estatisticamente analisados ($\alpha=0,05$). (Registro PROSPERO - CRD42019135744). **Resultados:** Após aplicação da estratégia de busca e remoção dos duplicados, 680 referências foram incluídas para leitura de título e resumo. Trinta e um artigos foram selecionados para leitura de texto completo, sendo 17 deles excluídos por diferentes razões. Ao final, 14 artigos foram selecionados para análise qualitativa, incluindo 817 próteses instaladas em 660 pacientes (idade média = 66,8 anos). A capacidade mastigatória dos pacientes reabilitados com sobredentaduras implanto-retidas (OVD) aumentou significativamente em comparação aos usuários de prótese total convencional (PT) ($P<0,05$). No entanto, as alterações observadas nos níveis sanguíneos da maioria dos nutrientes não foram significativas. A única exceção foi o folato sérico, que reduziu após 1 ano de uso da OVD (diferença média de 3,55 nmol/L; $P<0,001$). Os níveis séricos de albumina e vitamina B12 também reduziram em ambos os grupos (PT e OVD) após 1 ano ($P<0,001$). O índice de massa corporal manteve-se contante porém, o risco de desnutrição reduziu. A conversão da prótese parcial removível (PPR) em próteses retidas por implante (PPRIs) melhorou a mastigação, com aumento no relato de consumo energético diário e nos níveis de carboidratos, proteínas, cálcio, fibras e ferro ($P < 0.05$). A substituição das PPRIs por próteses fixas implanto-suportadas aumentou o consumo de fibras, cálcio e ferro, com significativa redução nos níveis de colesterol total. Em relação aos níveis séricos dos nutrientes, não foi constatada alterações após o uso de próteses parciais sobre implantes. **Conclusões:** Embora o uso de próteses sobre implantes melhore significativamente a função mastigatória, o estado nutricional parece ser pouco afetado. Não foi possível estabelecer uma relação de causa-efeito entre a mastigação e a nutrição em pacientes usuários de próteses sobre implante.

Palavras-chave: Prótese dentária suportada por implante; Nutrição; Revisão sistemática; Meta-análise.

ABSTRACT

Objectives: To systematically review the present literature in order to assess whether the use of implant-based prostheses affects dietary intake (serum concentration of nutrients, diet questionnaires, diet intake assessment and anthropometric measurements) of elderly patients. A possible cause-effect interaction between nutrition and mastication was also assessed.

Material and methods. Literature search included 6 electronic databases (until May 2019, last update July 2020) and 3 grey literature databases, without language, publication time and follow-up restrictions. Only studies evaluating both masticatory and nutritional outcomes were included. Risk of bias was assessed, and data were analyzed ($\alpha=0.05$). (Review registration PROSPERO - CRD42019135744). **Results:** After applying the search strategy in the databases and removing duplicates, 680 references were included. After phase 1, 31 articles were selected, 17 of which were excluded for different reasons, after full text assessment. Therefore, fourteen articles were selected for qualitative analysis, including 817 prostheses installed in 660 patients (mean age = 66.8 years). Masticatory function of patients rehabilitated with implant overdentures (IODs) improved significantly when compared to conventional complete dentures (CDs) wearers ($P<0.05$). However, changes in the blood levels of most nutrients were not significant, except for serum folate that decreased after 1 year of IOD use (mean difference 3.55 nmol/L; $P=0.001$). The serum levels of albumin and vitamin B12 also decreased in the PT and OVD groups after one year of follow-up. There were no differences in body mass index, but the risk of malnutrition was reduced ($P=0.001$). The conversion of removable partial dentures into implant-retained partial dentures (IRPDs) improved masticatory function, increasing daily energy consumption and levels of carbohydrates, protein, calcium, fiber, and iron ($P <0.05$). Replacement of IRPDs with fixed implant-supported dentures increased fiber, calcium and iron intake, resulting in lower total cholesterol levels. No changes in blood nutrient levels were observed after the use of implant-based prostheses in partially edentulous patients **Conclusions:** Although the use of implant-based prostheses significantly improves masticatory function, nutritional status seems to be barely affected. It was not possible to establish a cause-effect relationship between nutrition and mastication of implant prostheses wearers.

Keywords: Implant-supported dental prosthesis. Nutrition Assessment. Systematic review. Meta-analysis.

LISTA DE FIGURAS

- Figure 1.** Flowchart of the screening process (adapted from PRISMA)..... 53
- Figure 2.** Summary of the risk of bias assessment for the different study designs. 2.1 Risk of bias assessment for randomized clinical trials (Cochrane Collaboration’s tool). 2.2 Risk of bias assessment for paired clinical trials (Joanna Briggs Institute Critical Appraisal Non-randomized studies (Quasi-randomized experimental studies) Checklist). 2.3. Risk of bias assessment for cohort studies (“Meta-Analysis of Statistics Assessment and Review Instrument” (JBI - MASTARI) critical appraisal tools).....54
- Figure 3.** Forest plot evaluating the blood level of different nutrients, comparing conventional complete denture (CD) to implant overdenture (IOD) wearers after 12 months of use. A, Albumin protein levels (g/L). B, Serum folate levels (nmol/L). C, C-reactive protein levels (mg/L). D, Vitamin B12 (pmol/L). E, Red Blood Cell Folate levels (nmol/L). F, Carotene levels (g/L). G, Red Blood Cells ($\times 10^{12}$). H, Hemoglobin levels (g/L). I, Total lymph ($\times 10^9$)..... 55
- Figure 4.** Forest plot evaluating the blood level of several nutrients, comparing at baseline and 12 months after the use of both the conventional complete dentures (CDs) and the implant overdentures (IODs). A, Albumin levels (g/L) of CD wearers. B, Albumin levels (g/L) of IOD wearers. C, C-reactive protein levels (mg/L) of CD wearers. D, C-reactive protein levels (mg/L) of IOD wearers. E, Vitamin B12 (pmol/L) of CD wearers. F, Vitamin B12 (pmol/L) of IOD wearers. 56
- Figure 5.** Forest plot evaluating the nutritional intake (dietary diary) of conventional complete dentures (CDs) wearers in comparison to implant overdentures (IODs) wearers after 12 months of use. A, Fiber intake (g/day). B, Protein intake (g/day). C, Energy intake (kcal). D, Vitamin A intake ($\mu\text{g/day}$). E, Vitamin B6 intake (mg/day). F, Vitamin B12 intake (mg/day). G, Vitamin C intake (mg/day). H, Vitamin D intake (mg/day). I, Vitamin E intake (mg/day)..... 57

LISTA DE TABELAS

Table 1. Summary of descriptive characteristics of included studies (n=14).....	41
Table 2. Summary of mastication outcomes (mean/SD) of conventional complete denture (CD) and implant overdenture (IOD) reported.....	50

LISTA DE ABREVIATURAS E SIGLAS

PROSPERO - International prospective register of systematic reviews

OVD – Overdenture sobre implantes

PT – Prótese total

PPR – Prótese parcial removível convencional

PPRI – Prótese parcial removível sobre implantes

PPFI – Prótese parcial fixa sobre implantes

IOD – Implant overdenture

CD – Conventional denture

IRPD – Implant supported removable partial prosthesis

IFPD – Implant fixed partial prosthesis

PRISMA - Preferred Reporting Items for Systematic Reviews

LILACS - Latin American and Caribbean Health Sciences

A.P.B. – Adriana Pinto Bezerra

L.T.G. – Lorena Tavares Gama

T.M.S.V.G. – Thais Marques Simek Vega Gonçalves

BMI – Body Mass Index

MNA – Mini Nutritional Assessment

RCT – Randomized Clinical Trial

SUMÁRIO

1	INTRODUÇÃO.....	14
2	OBJETIVOS.....	18
	2.1 Objetivo Geral	18
	2.2 Objetivos Específicos	18
3	CAPÍTULO 1	19
4	CONCLUSÃO.....	83
	REFERÊNCIAS	84

1 INTRODUÇÃO

Uma nutrição adequada está diretamente relacionada a manutenção da saúde geral (HERNANDEZ MORANTE; GOMEZ MARTINEZ; MORILLAS-RUIZ, 2019; KOKA; GUPTA, 2018). Esse fator se torna ainda mais importante quando se trata de indivíduos com idade avançada, onde a ingestão insuficiente de nutrientes essenciais, provenientes de alimentos naturais como frutas e verduras, pode resultar em deficiências cognitivas, baixa imunidade e maior risco de doenças cardiovasculares e oncológicas, com consequente aumento da taxa de mortalidade (AUNE; GIOVANNUCCI; BOFFETTA; FADNES *et al.*, 2017; GLABSKA; GUZEK; GROELE; GUTKOWSKA, 2020).

O risco de malnutrição tende a aumentar com a idade, podendo ser influenciado por fatores biológicos e físicos, como as perdas dentárias (AHMED; HABOUBI, 2010). Cerca de 10% dos adultos com mais de 50 anos apresentam algum grau de edentulismo (TYROVOLAS; KOYANAGI; PANAGIOTAKOS; HARO *et al.*, 2016) e essa ausência total ou parcial dos dentes, associada ao uso de próteses mal adaptadas, reduz a capacidade mastigatória, com consequente redução no consumo de alimentos consistentes e fibrosos (SCHIMMEL; KATSOULIS; GENTON; MULLER, 2015; VERLAAN; LIGTHART-MELIS; WIJERS; CEDERHOLM *et al.*, 2017).

Vários estudos (IWASAKI; TAYLOR; MANZ; YOSHIHARA *et al.*, 2014; JAUHAINEN; MANNISTO; YLOSTALO; VEHKALAHTI *et al.*, 2017; MARSHALL; WARREN; HAND; XIE *et al.*, 2002; SCHIMMEL; KATSOULIS; GENTON; MULLER, 2015) têm demonstrado que a condição oral do indivíduo impacta a qualidade nutricional da dieta. O número de dentes remanescentes, assim como a condição da reabilitação protética, influenciam diretamente as escolhas nutricionais do indivíduo (JAUHAINEN; MANNISTO; YLOSTALO; VEHKALAHTI *et al.*, 2017). Usuários de próteses totais ou próteses mal adaptadas, por exemplo, optam por dietas menos saudáveis, com grande quantidade de alimentos industrializados e/ou de consistência mais macia que, geralmente, possuem menor valor nutricional (IWASAKI; TAYLOR; MANZ; YOSHIHARA *et al.*, 2014; JAUHAINEN; MANNISTO; YLOSTALO; VEHKALAHTI *et al.*, 2017; MARSHALL; WARREN; HAND; XIE *et al.*, 2002). Em acréscimo, usuários de próteses mal adaptadas reduzem a ingestão de alimentos ricos em proteínas, potássio, cálcio e vitaminas D, E, B6 e B12 em comparação aos pacientes

dentados. Da mesma forma, pacientes parcialmente dentados ingerem menos proteína, potássio, cálcio, folato, fibras e vitaminas A, D, E e B6, que pacientes completamente dentados (IWASAKI; TAYLOR; MANZ; YOSHIHARA *et al.*, 2014). Nesse sentido, seria lógico supor que o aumento da retenção e estabilidade das próteses, com a incorporação de implantes osseointegrados, poderia melhorar, de forma direta e até mesmo automática, a qualidade da nutrição. Entretanto, a relação entre a função mastigatória e a ingestão nutricional ainda é bastante controversa. Estudos anteriores ainda não conseguiram demonstrar uma relação direta de causa e efeito entre esses dois fatores (GAEWKHIEW; SABBAH; BERNABE, 2017; HUTTON; FEINE; MORAIS, 2002; YAMAZAKI; MARTINIUK; IRIE; SOKEJIMA *et al.*, 2016). Sabe-se que a apenas a instalação de próteses totais convencionais bem adaptadas não resulta em grandes mudanças nos hábitos alimentares dos pacientes (FONTIJN-TEKAMP; VAN DER BILT; ABBINK; BOSMAN, 2004; MORAIS; HEYDECKE; PAWLIUK; LUND *et al.*, 2003; N'GOM P; WODA, 2002). Além da dificuldade em triturar alimentos mais consistentes e fibrosos, a dieta depende de outros fatores, tais como preferências, hábitos individuais, cultura familiar ou regional, cultura religiosa, status sócio-econômico, mobilidade e a saúde geral do indivíduo (KOSSIONI, 2018). De qualquer forma, a reduzida retenção e estabilidade das próteses convencionais parece influenciar no consumo e seleção de certos alimentos.

Atualmente, os implantes dentários são ferramentas importantes na reabilitação de pacientes total ou parcialmente edêntulos, pois aumentam a retenção e estabilidade das próteses, conferindo maior conforto ao paciente principalmente durante a alimentação. A literatura revela ainda que o uso de próteses sobre implantes aumenta significativamente a capacidade mastigatória e a força de mordida, com reflexos na qualidade de vida, satisfação geral e adesão do paciente ao tratamento (BOVEN; RAGHOEBAR; VISSINK; MEIJER, 2015; CAMPOS; GONCALVES; RODRIGUES GARCIA, 2014; GONCALVES; CAMPOS; GARCIA, 2015; KRAUSCH-HOFMANN; CUYPERS; IVANOVA; DUYCK, 2018; ALLEN; MCMILLAN, 2002; AWAD; MORAIS; WOLLIN; KHALIL *et al.*, 2012; MORAIS; HEYDECKE; PAWLIUK; LUND *et al.*, 2003; N'GOM P; WODA, 2002). Gjengedal *et al.* (2012) e Muller *et al.* (2013), observaram ainda, que a substituição de próteses totais convencionais por sobredentaduras implanto-retidas aumentou a força de mordida e performance mastigatória, quando comparados aos pacientes cujas próteses convencionais foram

apenas reembasadas (GJENGEDAL; DAHL; LAVIK; TROVIK *et al.*, 2012; MULLER; DUVERNAY; LOUP; VAZQUEZ *et al.*, 2013). Estudos em pacientes parcialmente edêntulos também relatam vantagens no uso de próteses sobre implante com redução no número de ciclos mastigatórios e no tamanho da partícula deglutida (CAMPOS; GONCALVES; RODRIGUES GARCIA, 2014; GONCALVES; CAMPOS; GARCIA, 2015; VAN KAMPEN; VAN DER BILT; CUNE; FONTIJN-TEKAMP *et al.*, 2004). Essa maior eficiência mastigatória poderia ter efeitos positivos na digestão e absorção de nutrientes (DE OLIVEIRA; FRIGERIO, 2004).

Em relação ao estado nutricional, os resultados são ainda bastante contraditórios visto que a mudança de hábitos alimentares é multifatorial. No caso de pacientes totalmente edêntulos, o sucesso do tratamento protético não resulta necessariamente em melhora da qualidade nutricional (ALLEN; MCMILLAN, 2002; SHINKAI; HATCH; RUGH; SAKAI *et al.*, 2002). Muller *et al.* (2013), constataram que a instalação de overdentures sobre implantes aumenta a força de mordida, com consequente aumento na espessura do músculo masseter, além de maior satisfação com o tratamento protético quando comparado a próteses totais convencionais. Porém, as alterações na avaliação nutricional não foram significativas, demonstrando que a qualidade da dieta não depende apenas do estado da arcada dentária ou da reabilitação propriamente (MULLER; DUVERNAY; LOUP; VAZQUEZ *et al.*, 2013). Por outro lado, idosos que recebem orientações nutricionais simples, em conjunto à instalação das novas próteses aumentam a ingestão de alimentos mais nutritivos, quando comparados a pacientes que não receberam qualquer orientação (SUZUKI; KANAZAWA; KOMAGAMINE; IWAKI *et al.*, 2019; SUZUKI; KANAZAWA; KOMAGAMINE; IWAKI *et al.*, 2018). Portanto, uma ação multidisciplinar, associando a reabilitação protética ao acompanhamento nutricional, parece ser importante para que os pacientes possam tirar proveito do melhor desempenho mastigatório promovido pela reabilitação com implantes (AGARWAL; MILLER; YAXLEY; ISENRING, 2013; YAMAZAKI; MARTINIUK; IRIE; SOKEJIMA *et al.*, 2016).

Em relação aos pacientes parcialmente edêntulos, há também relatos de aumento na ingestão de carboidratos, proteínas, fibras, cálcio e ferro após a conversão das próteses parciais removíveis convencionais (PPRs) em próteses parciais removíveis de extensão distal bilateral retidas por implantes (PPRIs)(CAMPOS; GONCALVES; RODRIGUES GARCIA, 2014). O uso de próteses parciais fixas implanto-suportadas revelou também

impacto positivo na ingestão de alimentos com menor qualidade nutricional (GONCALVES; CAMPOS; GARCIA, 2015; SCHIMMEL; KATSOULIS; GENTON; MULLER, 2015). Por outro lado, pouco se sabe sobre o real impacto dessas próteses sobre os níveis séricos e a absorção desses nutrientes.

As controvérsias sobre como o assunto são bastante evidentes e, até o presente momento, não há na literatura revisões publicadas que avaliem estado nutricional e a função mastigatória de forma concomitante. A avaliação de ambos os parâmetros em um mesmo paciente reduz o risco de viés e, por consequência, aumenta o poder da evidência gerada. Assim, o objetivo deste trabalho foi revisar sistematicamente a literatura, buscando estudos que avaliassem o efeito da reabilitação com implantes sobre o estado nutricional de pacientes completamente ou parcialmente edêntulos, a fim de responder a pergunta focada: “A reabilitação com próteses parciais ou totais, suportadas ou retidas por implantes, proporciona melhora no estado nutricional?”. Nessa revisão sistemática, a possível relação de causa-efeito entre mastigação e nutrição dos pacientes foi também analisada.

2 OBJETIVOS

2.1 OBJETIVO GERAL

Revisar sistematicamente a literatura a fim de avaliar o impacto do uso de próteses sobre implantes sobre a nutrição dos pacientes.

2.2 OBJETIVOS ESPECÍFICOS

- Avaliar os desfechos primários relacionados a nutrição (concentração sérica dos nutrientes, medidas antropométricas, ingestão nutricional, questionários sobre dieta), assim como a mastigação (função mastigatória, eficiência mastigatória, capacidade mastigatória, limiar de deglutição, força de mordida, espessura muscular, ciclo mastigatório e eletromiografia) de pacientes reabilitados com próteses sobre implantes;
- Avaliar estatisticamente, através de meta análises, os estudos incluídos por meio da comparação entre reabilitações convencionais e sobre implantes;
- Avaliar o risco de viés e o nível de evidência dos estudos incluídos;
- Avaliar uma possível relação de causa-efeito entre os parâmetros de mastigação e nutrição.

3 CAPÍTULO 1

Do implant-based prostheses affect nutrition? A systematic review with meta-analysis.

Adriana Pinto Bezerra, DMD,^a Lorena Gama Tavares, DMD,^b Luciano José Pereira, DMD, MS, PhD,^c Andries van der Bilt, PhD,^d Renata Cunha Matheus Rodrigues Garcia DMD, MS, PhD,^e Marie Agnes Peyron,^f Thais Marques Simek Vega Gonçalves DMD, MS, PhD.^g

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

^aGraduate Student, Department of Dentistry, Federal University of Santa Catarina (UFSC), Florianópolis, Santa Catarina, Brazil.

^bGraduate Student, Department of Prosthodontics and Periodontology, State University of Campinas (UNICAMP), Piracicaba, São Paulo, Brazil.

^cProfessor, Department of Health Sciences, Federal University of Lavras (UFLA), Lavras, Minas Gerais, Brazil.

^dProfessor, Department of Oral Surgery, University Medical Center Utrecht, Utrecht, Netherlands.

^eProfessor, Department of Prosthodontics and Periodontology, State University of Campinas (UNICAMP), Piracicaba, São Paulo, Brazil.

^fProfessor, Université Clermont, Auvergne, France.

^gProfessor, Department of Dentistry, Federal University of Santa Catarina (UFSC), Florianópolis, Santa Catarina, Brazil.

Corresponding author:

Dr. Thais Marques Simek Vega Gonçalves

Department of Dentistry, Federal University of Santa Catarina

R. Eng. Agrônômico Andrei Cristian Ferreira, s/n - Trindade, Florianópolis - SC, Brazil,

Zip Code: 88040-900, Business Phone number: +554837215845

E-mail: thais.goncalves@ufsc.br

Acknowledgements

The authors would like to acknowledge the assistance of the librarian Goretí M. Savi from the Federal University of Santa Catarina.

* Este manuscrito está configurado de acordo com as normas do *Clinical Nutrition*.

ABSTRACT

Background & aims. Debate still exists about the impact of implant-based prostheses on nutritional status of partially and complete edentulous patients. This review aims to investigate objective nutritional parameters to find out whether the nutrition is affected by implant-based prosthodontics use. A possible cause-effect interaction between mastication and nutrition was also evaluated.

Methods. Literature search included 6 databases (until May 2019, last update June 2020) and 3 grey literature databases, without language, publication time and follow-up restrictions. Only studies evaluating both masticatory and nutritional outcomes were included. Risk of bias and the level of the evidence were analyzed. Meta-analysis of the Nutritional parameters were performed ($\alpha = 0.05$). (Review registration PROSPERO - CRD42019135744).

Results. Fourteen articles were selected, including 817 prostheses installed in 660 patients (mean age = 66.8 years). Implant overdenture (IOD) wearers had higher mastication capacity in comparison to complete denture (CD) wearers ($p < 0.05$). No significant differences were observed in nutrient blood levels, except for serum folate that reduced in IOD group (mean difference 3.55 nmol/L; $p = 0.001$). Serum albumin and vitamin B12 levels were also lower in both CD and IOD groups after 1 year. No differences in body mass were observed, but risk of malnutrition reduced in IOD group. For partial edentulous, fixed and removable implant-based prostheses improved mastication, increasing short-term daily intake of carbohydrates, protein, calcium, fiber, and iron, with lower consumption of high cholesterol food. However, no long-term changes on nutrient blood levels were observed, expect for a slight increase of ferritin, cholinesterase, and reduced levels of folic acid and Vitamin A.

Conclusion. Current evidence indicates that mastication capacity improves after the use of implant-based prostheses, but nutrient blood levels seems to be hardly affected. It emphasizes the importance of a multidisciplinary team to promote significant nutritional changes and a better health to the patients.

Keywords: mastication, nutrition, overdenture, dental implant, systematic review.

1. Introduction

The relationship between nutritional intake and mastication is still controversial. A significant reduction of chewing performance is observed with the loss of natural teeth.[1] Edentulous patients also consume fewer vegetables, less fiber and carotene, and more cholesterol, saturated fat and calories in comparison to dentate subjects.[2] Consequently, teeth loss is a major risk factor for malnourishment, especially among older adults.[3] In this sense, it is expected that increased masticatory capacity automatically improves nutrition. However, evidence of dietary quality improvements after oral rehabilitation appears to be less commonly observed.[4, 5] Furthermore, there is a lack of clarity around the cause-effect relationship between masticatory improvement and nutritional gain.

It is well known that implant-based treatment improves the masticatory process by reducing the number of chewing cycles until swallowing, whereas allowing the swallowing of smaller food particles.[6-8] These smaller food particles may have a positive effect on the digestion of food. However, to the best of authors knowledge, no previous reviews had assessed the meaningful changes of objective parameters such as the nutrient serum blood levels after the implant-based prostheses use, reducing the power of the evidence.

Food choice depends on several factors, such as individual preferences and habits, family or regional culture, religious practice, economic status, mobility and general health.[9] People also tend to adapt their diet due to tooth loss, altering their nutritional intake because of difficulties in eating harder foods.[10-12] A previous review reported that, in edentulous patients, the nutrition seems to be barely affected by the chewing improvements of implant overdentures (IOD), but this conclusion was based on subjective parameters, such as diet questionnaires.[13] On the other hand, primary

studies[10, 12, 14, 15] have shown a higher intake of hard, tough and crisp foods (e.g. raw vegetables, fruits, and meat) by patients who received this type of prosthesis.

In partially edentulous patients, a paired design study revealed an augmented intake of carbohydrates, protein, fibre, calcium, and iron after the conversion of a conventional removable partial denture (RPD) into implant-retained bilateral distal extension removable partial denture (IRPD)[8] and then into an implant-supported fixed partial denture (IFPD).[7] However, this study was based on the subjective nutritional assessment. The evaluation of objective parameters, such as the serum blood levels, are important to support these conclusions.

In regards to the nutritional risk, debate also exists about how masticatory improvements could reduce the risk of malnutrition. Although several reviews[13, 16-18] evaluated mastication and nutrition of edentulous patients, none of them had assessed both outcomes in the same patient or focused on the cause-effect relationship between these two variables. Additionally, these previous reviews were focused on completely edentulous patients solely, and several methodological limitations were evident, including the limited amount of database (without grey literature)[13, 16, 18] and keywords[17] searching, besides the language restrictions.[18] Moreover, none of them[13, 17, 18] had assessed objective parameters such as the nutrient serum blood levels, which reduces the power of the evidence. Therefore, the aim of this research was to systematically review the literature and investigate the nutritional status of partial and complete edentulous patients, wearing conventional prostheses and implant-based prostheses. A possible cause-effect interaction between mastication improvements and nutrition gain was also analysed.

2. Material and methods

2.1. Protocol and Registration

The systematic review protocol was registered at the International Prospective Register of Systematic Reviews (PROSPERO) under number CRD42019135744. This systematic review was conducted by following the Preferred Reporting Items for Systematic Reviews (PRISMA) statement.[19]

2.2. Eligibility Criteria

Prospective controlled clinical studies, randomized clinical trials, prospective studies, paired design studies (before and after) and observational studies evaluating the mastication and nutritional outcomes of partially or completely edentulous patients, who received implant-based prosthodontics, were selected. No restrictions on the language, time of publication, and period of follow-up were applied.

The exclusion criteria were: 1) Studies with completely dentate individuals; 2) Studies that did not report mastication outcomes; 3) Studies that did not report nutrition outcomes; 4) Studies that reported individuals with signs and symptoms of craniomandibular or temporomandibular disorders or undergoing surgical or other simultaneous treatment; 5) Studies with single tooth rehabilitation; 6) Studies not evaluating partially or completely edentulous patients who have received implant-retained or supported prostheses; 7) Reviews, letters, conference abstracts, personal opinions, case reports, technique articles, animal models or experimental *in vitro* or *in silico* studies; 8) Studies with missing data and/or not informed by the author; and 9) Articles not found and/or not provided by the author.

2.3. Information Sources

A literature search using PubMed/Medline, Embase, Latin American and Caribbean Health Sciences (LILACS), Scopus, Web of Science, and The Cochrane Library (CENTRAL) databases was conducted up to May 2019 with a last update in June 2020 (Supplemental File 1). Furthermore, grey literature (Google Scholar, Proquest

Dissertations and Thesis and Open Gray databases) and references of the included studies were also consulted, following the recommendation of Greenhalgh and Peacock.[20] Duplicates were removed by using appropriate software (EndNote X9, Thomson Reuters).

2.4. Study Selection

Study selection was independently performed by two trained reviewers (A.P.B and L.T.G.) in a two-phase process: titles/abstracts and full texts. Any disagreement in both phases was resolved by discussion until a mutual agreement between the two reviewers was attained. Discrepancies were solved in a consensus session with the study coordinator (T.M.S.V.G.). After the full-text reading, references were excluded by using eligibility criteria (Supplemental File 2).

2.5. Data Collection Process

Data extraction from included papers were independently registered by two researchers (A.P.B and L.T.G). The data collected included study characteristics (author, year of publication, study design, and country), population characteristics (sample size, gender, and age of participants), intervention characteristics (type of prosthesis, dental arch, number and characteristics of implants, groups of comparison, and follow-up time) and outcome characteristics (dropouts, mastication and objective and subjective nutritional outcomes, and main conclusions). In order to retrieve any pertinent unreported information, the corresponding authors was contacted with up to three attempts.

2.6. Risk of Bias

Methodological quality and risk of bias were independently assessed by the two reviewers (A.P.B and L.T.G) using different critical appraisal tools, according to each type of study. The Cochrane Collaboration's tool[21] was used for analysing the randomized clinical trials, whereas the paired clinical trials were evaluated using the

Joanna Briggs Institute critical appraisal checklist for quasi-experimental studies (non-randomized experimental studies) and the methodological quality of observational studies was evaluated using “Meta-Analysis of Statistics Assessment and Review Instrument” (JBI - MASTARI) critical appraisal tools.[22] Disagreements were resolved during a consensus meeting with the study coordinator (T.M.S.V.G.). The risk of bias was defined as: a) low risk (bias, if present, is unlikely to seriously alter the results); b) unclear risk (a risk of bias that raises some doubt about the results; and c) high risk (bias may seriously alter the results).

2.7. Level of Evidence

The Grading of Recommendations Assessment, Development and Evaluation (GRADE) criteria was used to assess the overall quality of evidence based on the rating of risk of bias, consistency, directness, precision, and publication bias. A summary of findings table was generated using online software (GRADEpro GDT; the GRADE Working Group).

2.8. Statistical Analysis

The individual results were combined using Mantel-Haenszel analysis. Heterogeneity was assessed using I^2 statistics, and the mean difference was evaluated between continuous outcomes (conventional CDs x IODs; baseline x 12 months). The Review Manager software was used, and the results were described as forest plots. All tests were performed considering a significance level of 5%.

3. Results

3.1. Selection of the studies

The search strategy details are illustrated in a PRISMA flowchart (Fig. 1). The electronic search of the databases revealed 1199 records. Removal of duplicates resulted

in 680 references. After phase 1 screening, 29 studies were selected for phase 2 and two additional articles were included from the hand-search of the reference lists, resulting in 31 articles selected for full-text analysis. Thereafter, in phase 2 screening, 17 articles were excluded for different reasons (Supplemental File 2), totalling 14 selected articles. Examiners agreement expressed as Cohen's unweighted κ yielded $\kappa=.91$ for the full-text screening and final selection of the articles.

3.2.Methodological Quality (Risk of Bias Assessment)

Randomized clinical trials[5, 10, 15, 23-27] were evaluated by the Cochrane Collaboration's tool (Fig. 2.1). In the first domain, most of the studies adequately described the randomization process and were considered as low risk. However, one study presented an inadequate randomization method,[25] and in another, the randomization process was not described,[27] increasing the risk of selection bias. No information on the patient's allocation concealment was given in four studies,[10, 15, 23, 24] and these studies were therefore considered as unclear. One study[27] was considered as high risk for selection bias, since the IOD group was composed only of patients who completely agreed with the treatment costs.

All studies were considered as high risk for bias, since none of the selected studies described any type of blinding. However, it is very difficult to maintain blindness after implant treatment. Three studies[23, 24, 26] reported a significant rate of dropouts during follow-up. One study[27] presented incomplete outcome data, with attrition bias considered unclear. At last, four studies[5, 23, 24, 27] were considered as high risk for reporting bias, since the results for the primary outcomes were not fully described. Other sources of bias were also detected, including financial compensation for patient participation,[15] level of patient satisfaction with their CD at baseline,[25] and

incomplete description of the outcome assessment,[27] jeopardizing the reproducibility of the study.

Most of the paired clinical trials[7, 8, 28-30] presented a low risk for bias, except for the control group and statistical analysis (Fig. 2.2). According to the Joanna Briggs guidelines, paired clinical trial design (e.g. before and after) is not considered and an additional control group is required, which increased the risk of bias for this item in the majority of studies. Two studies[29, 30] also presented problems in selecting statistical tests, and they were considered at high risk for bias.

Only one observational cohort study[31] was included. According to the JBI-MAStARI critical appraisal tool, this study presented a high risk of bias due to insufficient follow-up time, and subjective outcomes that were prone to patients' collaboration.

3.3. Certainty assessment of level of evidence by GRADE tool

Confidence in cumulative evidence was considered low or very low according to the GRADE criteria. Small number of participants included in the comparisons raised some concerns regarding the precision of the estimate, therefore imprecision was judged to be serious. Risk of bias was judged to be very serious in GRADE analysis due to the problems with allocation concealment, blinding of participants and selective reporting of outcomes.

3.4. Study characteristics

The included studies were published between 1998 and 2019. A total of 660 patients with age ranging from 52 to 85 years (mean of 66.8 years) were rehabilitated. A total of 817 prostheses were installed: 398 conventional CDs, 367 IODs, 8 conventional RPDs, 24 IRPDs and 20 IFPD (Table 1). Out of the 14 included articles, 11 articles investigated complete edentulous patients, reporting outcomes of conventional CDs and IOD.[5, 10, 15, 23-29, 31] The remaining 3 articles[7, 8, 30] evaluated partially

edentulous patients. One study evaluated the same patient using a conventional RPDs and then an IRPDs,[8] and the other studies reported results comparing outcomes of IRPDs and implant-fixed partial denture wearers.[7, 30]

Different methods were used to evaluate mastication, including masticatory performance,[23, 28, 29] masticatory efficiency,[30] chewing efficiency,[26] analysis of mandibular movements,[23, 28] swallowing threshold,[7, 8] bite force,[23, 26] masseter muscle thickness,[26] masticatory ability questionnaires,[10, 15, 23, 25-27] and perceived chewing ability.[31] Similarly, the nutritional status was heterogeneous and generally included the blood level analysis of different nutrients,[5, 10, 15, 26, 30, 31] nutritional intake (daily diet assessment),[5, 7, 8, 10, 24, 25, 28, 31] Mini Nutritional Assessment (MNA),[26, 27, 29, 30] anthropometric measurements (body mass index (BMI)).[5, 10, 26, 30]

3.5. Individual results for complete edentulous patients

Studies comparing nutritional status in conventional CD and IOD wearers presented more homogeneous methods, allowing data meta-analyses. The first analysis considered the comparison between CD and IOD wearers after 12 months of prosthesis use (Fig. 3). The Mantel-Haenszel test was applied with fixed effects (I^2 varied from 0% to 45%). Only the serum folate level reduced 3.55 nmol/L (95% CI - 1.37 to 5.73) in IOD wearers ($p = 0.001$) (Fig. 3.2). No differences between the CD and IOD groups were found for the remaining nutrients ($p > 0.05$).

Comparing serum levels at baseline to those after 12 months of both prostheses (fixed effects meta-analyses, $I^2=0\%$), significant differences were observed in albumin (CD - mean difference of 0.81g/L (95% CI: 0.13 to 1.49) ($p = 0.02$) (Fig. 4.1.1) and IOD - mean difference of 1.31g/L (95% CI: 0.68 to 1.93) ($p < 0.0001$) (Fig. 4.1.2)). Similarly, the levels of vitamin B12 also changed after 1 year in both groups (CD - mean difference

of 50.58 pmol/L (95% CI: 25.78 to 75.38) ($p < 0.0001$) (Fig. 4.3.1); IOD - mean difference of 43.28 pmol/L (95% CI: 22.08 to 64.49) ($p < 0.0001$) (Fig. 4.3.2)). No significant differences were observed for the remaining nutrients ($p > 0.05$) (Fig. 4).

Nutritional intake outcomes obtained from validated dietary dairies (Mantel-Haenszel of fixed effects, $I^2 = 0\%$) showed no significant differences for any of the macro- or micronutrients when comparing conventional CD and IOD wearers ($p > 0.05$) (Fig. 5).

In regards to the nutritional risk, only two studies[27, 29] compared MNA of CD and IOD wearers, revealing a significant improvement after 6 months of implant rehabilitation. An important reduction in the number of patients at risk for malnutrition[27, 29] and malnourished[27] and a substantial increment of well-nourished subjects was reported.[27, 29]

Regarding anthropometric measurements, BMI was reported in two studies,[15, 26] but no differences were found (fixed effects meta-analyses, $I^2 = 0\%$) when comparing the CD to IOD groups (-0.07 (95% CI: -0.87 to 0.73; $p = 0.86$)). Similarly, no differences were found in BMI between baseline and 12 months of prosthesis use for both conventional CD (-0.07 (95% CI: -1.25 to 1.11; $p = 0.91$)) and IOD wearers (0.36 (95% CI: -0.75 to 1.48; $p = 0.53$)).

Mastication comparisons between conventional CD and IOD wearers were reported in two randomized clinical trials (RCTs)[23, 24, 26], two paired controlled studies[28, 29] and one cohort study[31] (Table 2). In general, the definition and masticatory methodology was extremely diverse, increasing the heterogeneity, and jeopardizing data meta-analysis. For instance, in the first paired controlled study,[28] masticatory performance was reported as the median particle size (X_{50}), while in the other two studies,[23, 29] this variable was expressed as a percentage. In addition, two

studies[28, 29] had used the artificial material “Optocal” as a test food, while the other two applied peanuts and raw carrots.[23]

Most of the studies[23, 28, 29] revealed significant better results in masticatory performance in the IOD group ($p < 0.05$). Patients wearing IODs had also developed significantly higher maximum voluntary bite forces over the follow-up time as compared to patients wearing CDs ($p < 0.05$).[26] Furthermore, masseter muscle thickness significantly increased in the IOD group on the preferred side (interaction term: $p = 0.028$), while no changes were observed in the control CD group ($p > 0.05$).[26] Perceived chewing ability was also improved after 6 months of IOD use ($p = 0.031$).[31]

3.6. Individual results for partially edentulous patients

Only three papers[7, 8, 30] investigated partially edentulous patients, and two of these papers[7, 8] were derived from the same experiment. This paired clinical trial evaluated partially edentulous patients before and after the conversion of a conventional mandibular RPD into IRPD in the first published paper.[8] In the second paper,[7] the same patients were evaluated before and after the replacement of the IRPD by a IFPD . In both papers, mastication and nutritional status were analysed after 2 months of use of each prosthetic rehabilitation.

The third study[30] analysed partially edentulous patients wearing a combined IRPD and IFPD. Masticatory and nutritional outcomes were assessed after 6 and 12 months of rehabilitation.[30] As the prostheses were combined in the same patient, authors classified the treatment as implant prosthetic therapy, without separating the type of prosthesis in the results,[30] which prevented data meta-analysis.

Nutritional status was reported with the nutritional intake (3-day dietary record),[7, 8, 30] dietary behaviour questionnaire[30] and nutrient blood sample

analysis[30]. In general, differences in anthropometric outcomes, such as BMI, were not observed in the selected studies.[7, 8, 30]

In regards to the haematological markers, significant increments in cholinesterase ($p = 0.012$) and ferritin ($p = 0.003$), with significant reduction on folic acid ($p = 0.019$) and vitamin A ($p = 0.004$) were observed after 12 months of implant-based prosthesis use by partially edentulous patients.[30] However, in this study, no changes in subjective reported nutrient intake or food choices ($p > 0.05$) were noticed.[30]

In contrast, the subjective daily diet record reported by the other study[7, 8] showed an increment in daily energy ($p = 0.008$) and higher consumption of carbohydrates ($P=0.016$), protein ($p = 0.023$), calcium ($p = 0.008$), fibre ($p = 0.016$), and iron ($p = 0.016$) after the conversion of conventional RPDs into IRPDs.[8] When IRPDs were replaced by IFPD, higher intakes of fibre ($p = 0.007$), calcium ($p = 0.002$) and iron ($p = 0.03$) and a significant reduction in cholesterol levels ($p = 0.02$) were observed.[7]

Mastication of partially edentulous patients was assessed by swallowing threshold[7, 8] and masticatory efficiency tests.[30] According to the results, no differences were found in number of masticatory cycles needed for swallowing when comparing patients using RPDs and IRPDs ($p > 0.05$). Nonetheless, the median particle size (X_{50}) was significantly smaller ($p = 0.008$) after the conversion of conventional RPDs into IRPDs.[8]

The comparison between IRPDs and IFPD showed a significant reduction in both the number of chewing cycles ($p = 0.006$) and the X_{50} values ($p = 0.002$) when implant fixed prosthodontics were installed.[7] Similar results were also observed in Wostmann et al. study[30] with significant improvement in masticatory efficiency 6 months after implant prosthetic therapy ($p < 0.001$).

4. Discussion

This is the first time that objective nutritional data of nutrient blood levels are meta-analysed to assess the impact of implant-based prosthodontic on the nutritional status of partially and complete edentulous patients. The report of both groups of edentulous in a single systematic review is important to give a panoramic overview of how implant-based prosthodontics are influencing the nutrition. Although both masticatory and nutritional outcomes were assessed in the same patient, mastication methodologies were highly heterogeneous, making it difficult to perform specific analyses or to assess the cause-effect relationship between these two different outcomes.

Most of the studies evaluating completely edentulous patients reported a significant masticatory improvement after rehabilitation with IODs. According to Amaral et al.,[28] the better retention and stability of the IODs increases the resistance of the prosthesis against horizontal movements, and it result in higher masticatory muscle activity as a consequence, contributing to explain the reduction of the particle size observed in IOD group. Higher bite force was also related to the IOD group.[32] On the other hand, the effects on mastication seems to be closely dependent of the employed methodology.[28, 29] For instance, when the mixing ability test was applied, the mastication remained similar in both CD and IOD groups.[32] Previous studies reported a weak correlation between mixing ability and bite force, but a strong correlation between bite force and masseter muscle thickness[33] or masticatory performance when the sieving method is applied.[1] Therefore, it seems that some methods are more sensible to detect differences than others, explaining, in parts, these contrasting results.

Although significant improvements were observed in mastication, the nutritional serum level of most nutrients seems to be hardly affected. These were results in agreement with a previous review[16] that showed the modifying effect of IOD treatment on

nutritional status might be limited. Nevertheless, it has been shown that dietary intervention via nutritional advice along with masticatory improvements led to increased intake of fruits and vegetables, as well as reduced intake of saturated fats.[31] This emphasizes the importance of nutritional counselling in order to obtain significant changes of dietary patterns.

Only a slight reduction in serum folate levels was significant in IOD group when compared to CD wearers (mean difference 3.55 nmol/L in IOD, $p = 0.001$) (Fig. 3). This result was unexpected, since higher levels of serum folate are related to the consumption of natural foods, including leafy greens, legumes, nuts, seeds and raw vegetables.[34] However, interpretation of this finding requires further explanation. One concern relates to the diagnosis of nutrient deficiency. According to an epidemiological study,[35] the mean serum folate level for adults is 17.9 (± 10.9) nmol/L, and these levels remain constant in the age range 35–80 years. Moreover, deficiency of this nutrient is generally considered to be rare, even for the elderly.[36] The serum folate levels are also influenced by the environment, with mean levels varying from 11.3 (± 0.3) nmol/L, in subjects living in the community, to 8.2 (± 0.7) nmol/L, in those elderly living in nursing homes.[36] It is possible that, in the selected studies, good levels of serum folate were evident, indicating that the mean reduction of 3.55 nmol/mL seems to be irrelevant. However, to prove this theory, more longitudinal studies with longer follow-up times are necessary.

An interesting result was also observed for albumin and vitamin B12 levels using questionnaires to evaluate dietary intake. It was evident in meta-analyses that a significant reduction of the levels of both nutrients occurred after 12 months of use of both prostheses (CD and IOD). Albumin levels remained within the reference range (35 g/L), although the reduction in serum levels was significant.[37] These changes were also reported in a previous review,[16] and they were attributed to the subjectivity of the dietary diary. It

may be noted that a meta-analysis of objective serum levels revealed no significant differences in both albumin and vitamin B12 parameters. Second, although albumin has been used as an indicator of nutritional status for many years (along with other serum components), recent studies have shown that albumin levels may be easily affected by injury, illness and acute inflammation.[38-40] The current consensus is that laboratory markers are not reliable by themselves, but they could be used as a complement to a thorough physical examination.[39] In summary, the reduction observed in the daily food intake obtained in questionnaires might not be clinically relevant and more related to fluctuations of acute illness, rather than in nutritional intake.

Similarly, dietary intake of vitamin B12 reduced after 12 months of use of both prostheses. This vitamin is responsible for brain health maintenance, cognitive function and bone healing, especially in older individuals[41]. Again, the mean values observed in the selected studies were within the regular range of the elderly population.[42, 43] Serum levels of vitamin B12 are not only related to food intake but also to the ageing process and gastric diseases affecting the normal absorption of this nutrient.[41, 43] It has been proposed that B12-deficient persons should present with a level < 260 pmol/L.[35] The mean reduction of 50.58 pmol/L and 43.28 pmol/L observed in the CD and IOD groups, respectively, does not seem critical.

Another way of assessing nutritional status is through anthropometric evaluation. Most studies[7, 8, 10, 15, 26, 28, 30] included in this review used BMI as the only parameter for this evaluation. Meta-analyses showed no significant differences in BMI when comparing data at baseline and 12 months after rehabilitation or when comparing the use of both CDs and IODs. Yamazaki et al.[16] also found no significant differences in BMI after 6 months of prosthetic rehabilitation, suggesting that skinfold thickness and circumference of the arm would provide a better anthropometric evaluation, allowing a

more accurate assessment of fat distribution. In the present review, only one RCT[44] assessed the suggested parameters, revealing that, although there was an increment in the total percentage of body fat, the waist circumference and waist/hip ratio decreased in the IOD group, indicating a healthier distribution of adipose tissue in those subjects. More studies with longer follow-up times are necessary to evaluate the impact of the use of implant prosthodontics on BMI alterations.

A positive impact of implant rehabilitation was observed in the MNA analysis,[27, 29] with a significant reduction in the number of malnourished individuals and those at risk for malnutrition, with a consequent increment in the number of well-nourished subjects. This result is very important since a previous study has shown that 5% to 8% of the elderly living independently are considered malnourished, and it can increase up to 30% to 60% in the institutionalized population.[45] Although the MNA is a validated instrument, it is based on a subjective analysis, jeopardizing strong conclusions (especially because objective analyses of the serum nutrient levels were not altered).

The impact of implant prosthodontics over mastication and nutritional status seemed to be more evident in partially edentulous subjects, especially when subjective parameters are analysed. On the other hand, due to the small number of studies and heterogeneous methodologies, meta-analyses on nutritional or masticatory outcomes were not possible.

In a descriptive evaluation, the conversion of a conventional RDP into a IRDP significantly increased masticatory performance.[8] This improvement was also observed after the replacement of the IRDPs by an IFPD.[7] The number of chewing cycles until swallowing reduced and the size of the swallowed particles was also smaller after the replacement of the IRPD by the IFPD,[7] suggesting that the chewing became more efficient.[46] Likewise, in a second study visually analysing the degree of carrot

comminution, reported a significant improvement in mastication after 6 months of use of implant prosthodontics ($P < 0.001$).[30]

Similar to completely edentulous patients, no significant differences were found on serum blood levels of most nutrients after the installation of partial implant prostheses ($p > 0.05$).[30] The only exceptions were observed in cholinesterase and ferritin levels that increased after 6 months of implant prostheses use. In contrast, the vitamin A and folic acid decreased after 6 and 12 months, respectively.[30] These are important results since cholinesterase facilitates neuronal development and transmission, and it is a potential biomarker for neuronal diseases, such as Alzheimer's and Parkinson's.[47] Ferritin is an iron storage protein associated with the higher intake of meats, beans and leafy green vegetables. Higher levels of this nutrient are related to iron availability and homeostasis, being a biomarker for the diagnosis of anaemia.[48] On the other hand, the significant reduction on folic acid and vitamin A levels should be analysed carefully. In regards to the folic acid, similar reduction was also observed the studies with complete edentulous patients using IODs. It seems that high levels of this nutrient were present in the baseline (within the range considered normal for the age)[36] and this minor change, although significant, it was not clinically relevant. Similar reduction behaviour was noticed in the vitamin A serum levels.

As previously highlighted in folic acid analysis, the Vitamin A levels observed at baseline and after the use of a fixed and removable partial implant-based prosthesis are considered normal (within the reference range of 20 to 60 $\mu\text{g/dL}$).[49] It is reported that vitamin A blood levels might be reduced in case of acute inflammation and infection,[50] which may help to explain this minor changes observed.

The absence of correlation between improvements in mastication and several important micronutrients is not surprising. Nutrient absorption is not only influenced by

the chewing capacity but the age and conditions of the gastrointestinal tract are also important. Physiological digestion and absorption of nutrients requires a complex interaction between motor, secretory, digestive, and absorptive functions.[51] Output of salivary alpha-amylase, which is the most important salivary enzyme, comprises only about 15% of total amylase output, while the rest is attributable to pancreatic alpha-amylase,[51] which may compensate for small differences in swallowed particle size. The number of chewing cycles needed to prepare food for swallowing seems to be constant within a subject for one type of food,[11, 52] whereas large variations in the number of chewing cycles until swallowing are observed among subjects for the same type of food.[52, 53] Subjects who used a small number of chewing cycles before swallowing one food consistently also used small numbers for all other types of food. This implies that there are “slow” and “fast” swallowers (subjects who swallow any food after a relatively low or high number of cycles, respectively), which is not only partly the result of the individual’s physiology (including dental status) but also the result of the social context.[52]

Although only minor changes were reported in blood nutrient levels, the subjective analysis of nutritional intake seems to be more affected by the use of partial implant-based prosthesis. A significant increase in total daily energy and in intakes of carbohydrates, protein, calcium, fibre and iron, were reported after the conversion of conventional RDPs into IRDPs.[8] In the same sample, the replacement of IRDPs by IFPD also increased the intake of fibre, calcium, and iron, with significant reductions in cholesterol levels.[7] The higher intake of fibre facilitates the digestive transit and decreasing plasma cholesterol levels, which is associated with a lower risk of colorectal cancer.[7, 12] Fibre consumption is also associated with fatty acid production as a result of fermentation, with a significant reduction in intracellular and colonic pH.[54] This low

pH environment reduces mineral complexation and positively modulates bone mineral content, since this less complexed calcium is more easily absorbed.[54] Higher levels of iron might be also linked to the increased consumption of meat, while the increment in calcium levels enhance bone function, with consequent prevention of osteoporosis and related fractures.[55] However, these results might be considered with caution since in this paired study, each prostheses was use by the same patient only for 2 months. Moreover, this study was based on self-reported dietary data which is more prone to reporting bias.

None of the selected studies had tested the interaction between masticatory improvement and nutritional status, a direct association between these two outcomes seems to be unlikely, since the nutritional gain was almost insignificant after implant-based prostheses use. In spite of that, to prove such theory, future studies focusing on this cause-effect relationship are needed.

Regarding the methodological quality of the primary studies, some key problems with the randomization process, blinding, and incomplete outcomes were observed, increasing the risk of bias of the selected studies. A weak quality of evidence was also reported in a previous review evaluating the relationship between tooth loss and nutritional intake.[56] Another review[44] also showed that blindness of both patient and principal investigator is closely related to the outcome effect size, which is usually overestimated. Additionally, the high risk of estimation imprecisions, lead the confidence in cumulative evidence to be judged as low or very low. Thus, it is strongly recommended that future studies attempt to reduce the risk of bias by using high quality methods for evaluating treatment outcomes.

Even though in the literature there are a large number of reviews evaluating mastication after the use of implant prosthodontics, none of them evaluated nutritional

status at the same time, jeopardizing further conclusions regarding it. On the other hand, due to these restriction on studies selection, some important studies might have been missed. Another limitation of the present review is the limited amount of studies that investigated partially edentulous patients (3 of 14 studies). Moreover, only one of those three studies had considered the haematological analysis in its evaluation. Similarly, for IOD studies, all prostheses were installed on the mandibular arch and no information was available regarding maxillary rehabilitation; therefore, conclusions based on these data may be limited. Methodologies and follow-up periods strongly varied, jeopardizing outcome comparisons as well as meta-analysis. Most of the statistics were based on a small number of studies, which reduces the power of the evidence and further analysis of sensitivity, and heterogeneity of the plots were not able to be performed. Future clinical trials with more homogeneous methodologies are necessary to allow better outcomes comparisons.

5. Conclusions

Current evidence indicates that the nutrient blood levels are hardly affected by the use of implant-based prostheses in both completely and partially edentulous patient. The cause-effect relationship between masticatory improvements and nutritional gain was not reported in any of the primary studies, making it difficult to draw further conclusions. Nutritional changes seem to be more affected when dietary counselling is provided, showing the importance of a multidisciplinary team to promote significant improvements on the nutritional status.

Acknowledgments

The authors would like to acknowledge the assistance of the librarian Goreti M. Savi from the Federal University of Santa Catarina.

Funding

The authors declare the receipt of financial support by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES).

Conflicts of interest

No conflicts of interest were declared.

REFERENCES

- [1] Hatch JP, Shinkai RS, Sakai S, Rugh JD, Paunovich ED. Determinants of masticatory performance in dentate adults. *Arch Oral Biol* 2001;46:641-8.
- [2] Joshipura KJ, Willett WC, Douglass CW. The impact of edentulousness on food and nutrient intake. *J Am Dent Assoc.* 1996;127:459-67.
- [3] Kazemi S, Savabi G, Khazaei S, Savabi O, Esmailzadeh A, Keshteli AH, et al. Association between food intake and oral health in elderly: SEPAHAN systematic review no. 8. *Dent Res J.* 2011;8:S15-20.
- [4] Moynihan PJ, Butler TJ, Thomason JM, Jepson NJ. Nutrient intake in partially dentate patients: the effect of prosthetic rehabilitation. *J Dent.* 2000;28:557-63.
- [5] Muller K, Morais J, Feine J. Nutritional and anthropometric analysis of edentulous patients wearing implant overdentures or conventional dentures. *Braz Dent J.* 2008;19:145-50.
- [6] van Kampen FM, van der Bilt A, Cune MS, Fontijn-Tekamp FA, Bosman F. Masticatory function with implant-supported overdentures. *J Dent Res.* 2004;83:708-11.

- [7] Goncalves TM, Campos CH, Garcia RC. Effects of implant-based prostheses on mastication, nutritional intake, and oral health-related quality of life in partially edentulous patients: a paired clinical trial. *Int J Oral Maxillofac Implants*. 2015;30:391-6.
- [8] Campos CH, Goncalves TM, Rodrigues Garcia RC. Implant retainers for free-end removable partial dentures affect mastication and nutrient intake. *Clin Oral Implants Res*. 2014 Aug;25(8):957-61. doi: 10.1111/clr.12165
- [9] Kossioni AE. The Association of Poor Oral Health Parameters with Malnutrition in Older Adults: A Review Considering the Potential Implications for Cognitive Impairment. *Nutrients*. *Nutrients*. 2018 Nov 8;10(11):1709. doi: 10.3390/nu10111709.
- [10] Morais JA, Heydecke G, Pawliuk J, Lund JP, Feine JS. The effects of mandibular two-implant overdentures on nutrition in elderly edentulous individuals. *J Dent Res*. 2003 Jan;82(1):53-8. doi: 10.1177/154405910308200112.
- [11] Fontijn-Tekamp FA, Slagter AP, Van der Bilt A, Van't Hof MA, Kalk W, Jansen JA. Swallowing thresholds of mandibular implant-retained overdentures with variable portion sizes. *Clin Oral Implants Res*. 2004 Jun;15(3):375-80. doi: 10.1111/j.1600-0501.2004.01006.x.
- [12] N'Gom P I, Woda A. Influence of impaired mastication on nutrition. *J Prosthet Dent*. 2002 Jun;87(6):667-73. doi: 10.1067/mpr.2002.123229.
- [13] Boven GC, Raghoobar GM, Vissink A, Meijer HJ. Improving masticatory performance, bite force, nutritional state and patient's satisfaction with implant overdentures: a systematic review of the literature. *J Oral Rehabil*. 2015 Mar;42(3):220-33. doi: 10.1111/joor.12241.

- [14] Allen F, McMillan A. Food selection and perceptions of chewing ability following provision of implant and conventional prostheses in complete denture wearers. *Clin Oral Implants Res.* 2002 Jun;13(3):320-6. doi: 10.1034/j.1600-0501.2002.130313.x.
- [15] Awad MA, Morais JA, Wollin S, Khalil A, Gray-Donald K, Feine JS. Implant overdentures and nutrition: a randomized controlled trial. *J Dent Res.* 2012 Jan;91(1):39-46. doi: 10.1177/0022034511423396.
- [16] Yamazaki T, Martiniuk AL, Irie K, Sokejima S, Lee CM. Does a mandibular overdenture improve nutrient intake and markers of nutritional status better than conventional complete denture? A systematic review and meta-analysis. *BMJ Open* . 2016 Aug 3;6(8):e011799. doi: 10.1136/bmjopen-2016-011799.
- [17] Sanchez-Ayala A, Lagravere MO, Goncalves TM, Lucena SC, Barbosa CM. Nutritional effects of implant therapy in edentulous patients--a systematic review. *Implant Dent.* 2010 Jun;19(3):196-207. doi: 10.1097/ID.0b013e3181d46903.
- [18] McGowan L, McCrum LA, Watson S, Cardwell C, McGuinness B, Rutherford H, et al. The impact of oral rehabilitation coupled with healthy dietary advice on the nutritional status of adults: A systematic review and meta-analysis. *Crit Rev Food Sci Nutr* . 2020;60(13):2127-2147. doi: 10.1080/10408398.2019.1630600.
- [19] Moher D, Liberati A, Tetzlaff J, Altman DG, Group P. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA Statement. *Open Med.* 2009;3:e123-30.
- [20] Greenhalgh T, Peacock R. Effectiveness and efficiency of search methods in systematic reviews of complex evidence: audit of primary sources. *BMJ.* 2005 Nov 5;331(7524):1064-5. doi: 10.1136/bmj.38636.593461.68.
- [21] Higgins JPT GS. *Cochrane Handbook for Systematic Reviews of Interventions* Version 5.1.0 [updated March 2011]. The Cochrane Collaboration; 2011.

- [22] Institute TJB. Joanna Briggs Institute Reviewers' Manual: 2014 edition: The Joanna Briggs Institute; 2014.
- [23] Garrett NR, Kapur KK, Hamada MO, Roumanas ED, Freymiller E, Han T, et al. A randomized clinical trial comparing the efficacy of mandibular implant-supported overdentures and conventional dentures in diabetic patients. Part II. Comparisons of masticatory performance. *J Prosthet Dent*. 1998 Jun;79(6):632-40. doi: 10.1016/s0022-3913(98)70069-1.
- [24] Hamada MO, Garrett NR, Roumanas ED, Kapur KK, Freymiller E, Han T, et al. A randomized clinical trial comparing the efficacy of mandibular implant-supported overdentures and conventional dentures in diabetic patients. Part IV: Comparisons of dietary intake. *J Prosthet Dent*. 2001 Jan;85(1):53-60. doi: 10.1067/mpr.2001.112491.
- [25] Gjengedal H, Dahl L, Lavik A, Trovik TA, Berg E, Boe OE, et al. Randomized clinical trial comparing dietary intake in patients with implant-retained overdentures and conventionally relined denture. *Int J Prosthodont*. 2012;25(4):340-7.
- [26] Muller F, Duvernay E, Loup A, Vazquez L, Herrmann FR, Schimmel M. Implant-supported mandibular overdentures in very old adults: a randomized controlled trial. *J Dent Res*. 2013 Dec;92(12 Suppl):154S-60S. doi: 10.1177/0022034513509630
- [27] de Oliveira TR, Frigerio ML. Association between nutrition and the prosthetic condition in edentulous elderly. *Gerodontology*. 2004 Dec;21(4):205-8. doi: 10.1111/j.1741-2358.2004.00032.x.
- [28] Amaral CFD, Souza GA, Pinheiro MA, Campos CH, Garcia R. Sensorial Ability, Mastication and Nutrition of Single-Implant Overdentures Wearers. *Braz Dent J*. 2019;30(1):66-72. doi: 10.1590/0103-6440201902086.
- [29] Borges Tde F, Mendes FA, de Oliveira TR, do Prado CJ, das Neves FD. Overdenture with immediate load: mastication and nutrition. *Br J Nutr*. 2011;105:990-4.

- [30] Wostmann B, Simon T, Neuhauser-Berthold M, Rehmann P. Pilot Study on the Influence of Nutritional Counselling and Implant Therapy on the Nutritional Status in Dentally Compromised Patients. *PLoS One*. 2016 Jan 28;11(1):e0147193. doi: 10.1371/journal.pone.0147193.
- [31] Moynihan PJ, Elfeky A, Ellis JS, Seal CJ, Hyland RM, Thomason JM. Do implant-supported dentures facilitate efficacy of eating more healthily? *J Dent*. 2012 Oct;40(10):843-50. doi: 10.1016/j.jdent.2012.07.001.
- [32] Muller F, Hernandez M, Grutter L, Aracil-Kessler L, Weingart D, Schimmel M. Masseter muscle thickness, chewing efficiency and bite force in edentulous patients with fixed and removable implant-supported prostheses: a cross-sectional multicenter study. *Clin Oral Implants Res*. 2012 Feb;23(2):144-150. doi: 10.1111/j.1600-0501.2011.02213.x.
- [33] Schimmel M, Memedi K, Parga T, Katsoulis J, Muller F. Masticatory Performance and Maximum Bite and Lip Force Depend on the Type of Prosthesis. *Int J Prosthodont*. 2017;30(6):565–572. doi: 10.11607/ijp.5289.
- [34] Bailey LB, Stover PJ, McNulty H, Fenech MF, Gregory JF, 3rd, Mills JL, et al. Biomarkers of Nutrition for Development-Folate Review. *J Nutr*. 2015 Jul;145(7):1636S-1680S. doi: 10.3945/jn.114.206599.
- [35] Wahlin A, Backman L, Hultdin J, Adolfsson R, Nilsson LG. Reference values for serum levels of vitamin B12 and folic acid in a population-based sample of adults between 35 and 80 years of age. *Public Health Nutr*. 2002 Jun;5(3):505-11. doi: 10.1079/phn200167.
- [36] Hanger HC, Sainsbury R, Gilchrist NL, Beard ME, Duncan JM. A community study of vitamin B12 and folate levels in the elderly. *J Am Geriatr Soc*. 1991 Dec;39(12):1155-9. doi: 10.1111/j.1532-5415.1991.tb03566.x.

- [37] Cabrerizo S, Cuadras D, Gomez-Busto F, Artaza-Artabe I, Marin-Ciancas F, Malafarina V. Serum albumin and health in older people: Review and meta analysis. *Maturitas*. 2015 May;81(1):17-27. doi: 10.1016/j.maturitas.2015.02.009.
- [38] Keller U. Nutritional Laboratory Markers in Malnutrition. *J Clin Med*. 2019 May 31;8(6):775. doi: 10.3390/jcm8060775.
- [39] Bharadwaj S, Ginoya S, Tandon P, Gohel TD, Guirguis J, Vallabh H, et al. Malnutrition: laboratory markers vs nutritional assessment. *Gastroenterol Rep (Oxf)*. 2016 Nov;4(4):272-280. doi: 10.1093/gastro/gow013.
- [40] Zhang Z, Pereira SL, Luo M, Matheson EM. Evaluation of Blood Biomarkers Associated with Risk of Malnutrition in Older Adults: A Systematic Review and Meta-Analysis. *Nutrients*. 2017 Aug 3;9(8):829. doi: 10.3390/nu9080829.
- [41] Porter K, Hoey L, Hughes CF, Ward M, McNulty H. Causes, Consequences and Public Health Implications of Low B-Vitamin Status in Ageing. *Nutrients*. 2016 Nov 16;8(11):725. doi: 10.3390/nu8110725.
- [42] ter Borg S, Verlaan S, Hemsworth J, Mijnarends DM, Schols JM, Luiking YC, et al. Micronutrient intakes and potential inadequacies of community-dwelling older adults: a systematic review. *Br J Nutr*. 2015 Apr 28;113(8):1195-206. doi: 10.1017/S0007114515000203.
- [43] Obeid R, Heil SG, Verhoeven MMA, van den Heuvel E, de Groot L, Eussen S. Vitamin B12 Intake From Animal Foods, Biomarkers, and Health Aspects. *Front Nutr*. 2019 Jun 28;6:93. doi: 10.3389/fnut.2019.00093
- [44] Saltaji H, Armijo-Olivo S, Cummings GG, Amin M, da Costa BR, Flores-Mir C. Influence of blinding on treatment effect size estimate in randomized controlled trials of oral health interventions. *BMC Med Res Methodol*. 2018 May 18;18(1):42. doi: 10.1186/s12874-018-0491-0.

- [45] Guigoz Y. The Mini Nutritional Assessment (MNA) review of the literature--What does it tell us? *J Nutr Health Aging*. 2006;10:466-85; discussion 85-7.
- [46] Toman M, Toksavul S, Saracoglu A, Cura C, Hatipoglu A. Masticatory performance and mandibular movement patterns of patients with natural dentitions, complete dentures, and implant-supported overdentures. *Int J Prosthodont*. Mar-Apr 2012;25(2):135-7.
- [47] Bawaskar HS, Bawaskar PH, Bawaskar PH. RBC acetyl cholinesterase: A poor man's early diagnostic biomarker for familial alzheimer's and Parkinson's disease dementia. *J Neurosci Rural Pract*. 2015 Jan;6(1):33-8. doi: 10.4103/0976-3147.143187.
- [48] Anderson GJ, Frazer DM. Current understanding of iron homeostasis. *Am J Clin Nutr*. 2017 Dec;106(Suppl 6):1559S-1566S. doi: 10.3945/ajcn.117.155804.
- [49] Medicine Io. Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc. Washington DC: The National Academies Press; 2001. doi: 10.17226/10026
- [50] Rosales FJ, Ritter SJ, Zolfaghari R, Smith JE, Ross AC. Effects of acute inflammation on plasma retinol, retinol-binding protein, and its mRNA in the liver and kidneys of vitamin A-sufficient rats. *J Lipid Res*. 1996 May;37(5):962-71.
- [51] Keller J, Layer P. The Pathophysiology of Malabsorption. *Viszeralmedizin*. 2014;30:150-4.
- [52] van der Bilt A, Engelen L, Pereira LJ, van der Glas HW, Abbink JH. Oral physiology and mastication. *Physiol Behav*. 2006 Aug 30;89(1):22-7. doi: 10.1016/j.physbeh.2006.01.025.
- [53] Peyron MA, Mishellany A, Woda A. Particle size distribution of food boluses after mastication of six natural foods. *J Dent Res*. 2004 Jul;83(7):578-82. doi: 10.1177/154405910408300713.

[54] Weaver CM. Diet, gut microbiome, and bone health. *Curr Osteoporos Rep.* 2015 Apr;13(2):125-30. doi: 10.1007/s11914-015-0257-0.

[55] Krall E, Hayes C, Garcia R. How dentition status and masticatory function affect nutrient intake. *J Am Dent Assoc.* 1998 Sep;129(9):1261-9. doi: 10.14219/jada.archive.1998.0423.

[56] Gaewkhiew P, Sabbah W, Bernabe E. Does tooth loss affect dietary intake and nutritional status? A systematic review of longitudinal studies. *J Dent.* 2017 Dec;67:1-8. doi: 10.1016/j.jdent.2017.10.012.

Table 1. Summary of descriptive characteristics of included studies (n=14).

Author, year	Study design	Sample size (n/female)	Mean age ± Standard deviation (years)	Groups (n)	Follow-up time (months)	Treated arch	Mastication measurements	Nutrition measurements	Main conclusions
Amaral et al., 2019²⁸	Paired clinical trial	12 subjects/8 females	68.6 ± 5.2	Control: Conventional CD (n=12) Intervention : Single implant IOD (n=12)	2 months	Mandible	OSA Chewing movements Masticatory performance	3-day dietary records	Single implant IOD use had no effect on OSA, but significantly improved mastication and decreased sodium intake.

Awad et al., 2012¹⁵	Rando mized clinical trial	255 subjects/ 141 females	Control (69.7 ± 4.6)	Control: Conventional CD (n=128) Intervention : IOD (n=127)	T0) Baseline T1) 6months T2) 12 months	Mandible	Subjective chewing ability level	Blood plasma	IOD patients reported fewer difficulties chewing pieces of beef, vegetables, fruits, bread crust, and nuts than did those in the CD patients. However, IOD did not have a more positive effect on the nutritional state of elderly edentate individuals at post-treatment than new CDs.
---------------------------------------	----------------------------	---------------------------	--------------------------------	---	--	----------	-------------------------------------	--------------	---

Borges et al., 2011 ²⁹	Paired Clinical trial	20 subjects	59.2	Control: Conventional CD (n=20) Intervention : IOD (n=20)	T0) Baseline T1) 3 months T2) 6 months	Mandible	Masticatory Performance	MNA	Risk of malnutrition was higher in CD wearers, who also presented lower mastication. After the conversion of CDs into IODs, significant improvements were observed in both parameters. However, changing eating habits is a complex process and nutritional guidance seems to be crucial to reduce the
--	-----------------------	-------------	------	--	--	----------	-------------------------	-----	--

									risk of the patient not taking advantage of the masticatory improvements.
Campos et al., 2014⁸	Study 1: 8 subjects/ 6 females	60.1 ± 6.6	Study 1: RPD (n=8) IRPD (n=8)	2 months	Mandible	Swallowing threshold	- 3-day dietary records - BMI		The replacement of a conventional RPD with a IRPD significantly improves
Gonçalves et al., 2015⁷	Paired clinical trial			2 months	Mandible				chewing and nutritional intake, being a positive alternative for free-end mandibular ridge rehabilitation.
	Study 2: 12 subjects/ 8 females	62.6 ± 7.8	Study 2: IRPD (n=12) IFPD (n=12)			Swallowing threshold	3--day dietary records -BMI		

Both implant-based therapies are associated with substantial improvements in mastication and nutritional intake, but the impact of IFDP was higher in comparison to IRPD.

Garret et al., 1998²³	Rando mized clinical trial	89 subjects	Control (64.2 ± 7.4)	Control: Conventional CD (n=37)	T0 -Baseline T1- 6 months T2- 24 months	Mandible	Masticatory performance, Bite force	Dietary intake	IOD showed no significant advantage over the conventional CD for improving the
Hamada et al., 2001²⁴			(65.7 ± 6.4)	Intervention : IOD (n=52)			Electromyography		

Chewing movements	ability to comminute food.
Salivary flow rate	The replacement of old CDs with new CDs or IODs did not alter patient diets.
Oral stereognosis	Dietary intake is not readily changed or influenced by the type of prostheses of edentulous patients, increasing the importance of nutritional counselling.
Food clearance ability	
Oral tactile sensitivity	

Gjengedal et al., 2012²⁵	Rando mized clinical trial	60 subjects/ 33 females	Control (67) Intervention (68)	Control: Conventional CD (n=30) Intervention : IOD (n=30)	T0-Baseline T1- 3 months T2- 6 months T3- 12 months	Mandible	Self-administered questionnaire	Dietary assessment	There were no significant differences regarding food choices and nutrient intake between the IOD and relined CD groups. However, IOD group reported significantly better chewing ability, less food avoidance, and greater willingness to eat more of certain food items.
--	----------------------------	----------------------------	---	---	--	----------	---------------------------------	--------------------	---

Morais et al., 2003 ¹⁰	Rando mized clinical trial	60 subjects/ 36 female	Control (70.1) Intervention (69.6)	Control: Conventional CD (n=30) Intervention : IOD (n=30)	T0- Baseline T1- 6 months T2- 12 months	Mandible	Subjective chewing ability records	- 3-day dietary records - Blood parameters - BMI	Providing edentulous patients with low-cost mandibular IODs improves their dietary intake and nutritional state. Moreover, IOD wearers reported less difficulty in chewing and swallowing and a significant increment of food choices consumption.
Moynihan et al., 2012 ³¹	Cohort study	54 subjects/ 38 females	Control (72.5) Intervention	Control: Conventional CD (n=26)	T0 – Baseline T1 – 3 months	Mandible	Chewing satisfaction (VAS)	3-day dietary records	Dietary intervention benefits denture patients. IOD patients

			(66.3)	Intervention : IOD (n=28)	T2 – 6 months			Blood parameters	showed moderately greater dietary improvements compared with conventional denture patients.
Muller et al., 2013 ²⁶	Rando mized clinical trial	45 subjects/ 23 females	Control (84.1 ± 5.55) Intervention (85.0 ± 6.19)	Control: Conventional CD (n=23) Intervention : IOD (n=22)	T0- Baseline T1- 3 months T2- 12 months	Mandible	Chewing efficiency Bite force Masseter muscle thickness Saliva flow rate	- BMI - MNA - Blood parameters	Increased bite force and masseter muscle bulk indicate a functional and morphologic benefit from IOD, even for very old patients. However, the inconsistent findings

									in BMI, MNA, and blood markers reflect that nutritional intake is complex and not solely determined by the dental state.
Muller et al., 2008⁵	Rando mized clinical trial	53 subjects/ 22 female	Control (53) Intervention (52)	Control: Conventional CD (n=24) Intervention : IOD (n=29)	12 months	Mandible	Self-administered questionnaire	- BMI - Body composition - Blood parameters - Dietary intake assessment	Although the CD wearers reported having more difficulty in chewing hard foods, both groups appeared to have a similar nutritional status.

								It seems that the reportedly higher chewing difficulty did not discourage subjects from eating harder foods.
Oliveira & Frigerio, 2004²⁷	Rando mized clinical trial	40 subjects	N/D	Control: Conventional CD (n=23) Intervention : IOD (n=17)	13 months	Mandible	Chewing ability MNA	CD wearers can be more susceptible to malnutrition when compared to IOD wearers. This may be related to the higher ability of chewing observed in the IOD group. On the other

hand, the psychological condition of the elderly should be considered, since it affects food choices and diet.

Wostmann et al., 2016 ³⁰	Paired clinical trial	20 subjects/ 10 females	62.5 ± 7.80	IRPD (n=12) IFPD (n=8)	T0- Baseline T1- 3 months T2- 12 months	Maxilla and Mandible	Masticatory efficiency	- MNA - BMI - Blood parameters	Results provide strong indications of the functional advantages of implant prosthodontics. However, it is not possible to confirm the assumption that
--	-----------------------	----------------------------	-------------	-------------------------------	---	----------------------	------------------------	--------------------------------------	---

implant-prosthetic
rehabilitation of
patients with severely
reduced residual
dentition influences
nutritional status.

Complete denture (CD); implant overdenture (IOD); removable partial dentures (RPDs); implant-retained bilateral distal extension removable partial dentures (IRPDs); implant-supported fixed partial dentures (IFPD); Oral sensorimotor ability (OSA); mini nutritional assessment (MNA); body mass index (BMI).

Table 2. Summary of mastication outcomes (mean/SD) of conventional complete denture (CD) and implant overdenture (IOD) reported by the selected studies.

MASTICATION ANALYSIS	STUDY	CONVENTIONAL CD				IOD			
		Baseline	2/3 months	6 months	12 months	Baseline	2/3 months	6 months	12 months
Masticatory performance (X₅₀)	Amaral et al ²⁸		6.27 ± 0.84				4.57 ± 0.79		
	Borges et al ²⁹	14.33 ± 14.42						27.70 ± 17.46	
Masticatory performance (%)	Garret et al ²²	Peanuts		Peanuts		Peanuts		Peanuts	
		42.1 ± 16.1		41.3 ± 15.5		35.0 ± 14.3		35.7 ± 13.6	
		Carrots		Carrots		Carrots		Carrots	
		69.4 ± 26.9		68.2 ± 25.8		60.2 ± 25.8		61.4 ± 24.9	
Swallowing threshold (%)	Garret et al ²²	Peanuts		Peanuts		Peanuts		Peanuts	
		59.4 ± 24.1		61.1 ± 19.4		53.1 ± 24.1		61.5 ± 16.3	
		Carrots		Carrots		Carrots		Carrots	
		69.1 ± 27.5		79.0 ± 20.1		63.8 ± 28.2		78.3 ± 16.4	

Mixing ability test (SD/Hue)	Muller et al ³³	1.150 ± 0.139	1.25 ± 0.27	.	1.192 ± 0.221	1.490 ± 0.283	1.52 ± 0.47	.	1.328 ± 0.387
Bite force (N)	Muller et al ³³	21.2 ± 26.95	25.25 ± 29.25	.	26.4 ± 28.39	44.3 ± 38.22	62.8 ± 54.65	.	73.0 ± 78.01
Masseter muscle thickness (mm)	Muller et al ³³	Preferred	Preferred	.	Preferred	Preferred	Preferred	.	Preferred
		10.7 ± 1.89	10.7 ± 1.82	.	10.7 ± 1.87	11.3 ± 1.92	11.7 ± 1.98	.	11.7 ± 2.19
		Non-Preferred	Non-Preferred	.	Non-Preferred	Non-Preferred	Non-Preferred	.	Non-
		10.7 ± 1.68	10.8 ± 1.52	.	10.8 ± 1.55	11.2 ± 1.96	11.6 ± 2.10	.	Preferred 11.5 ± 2.15

FIGURES

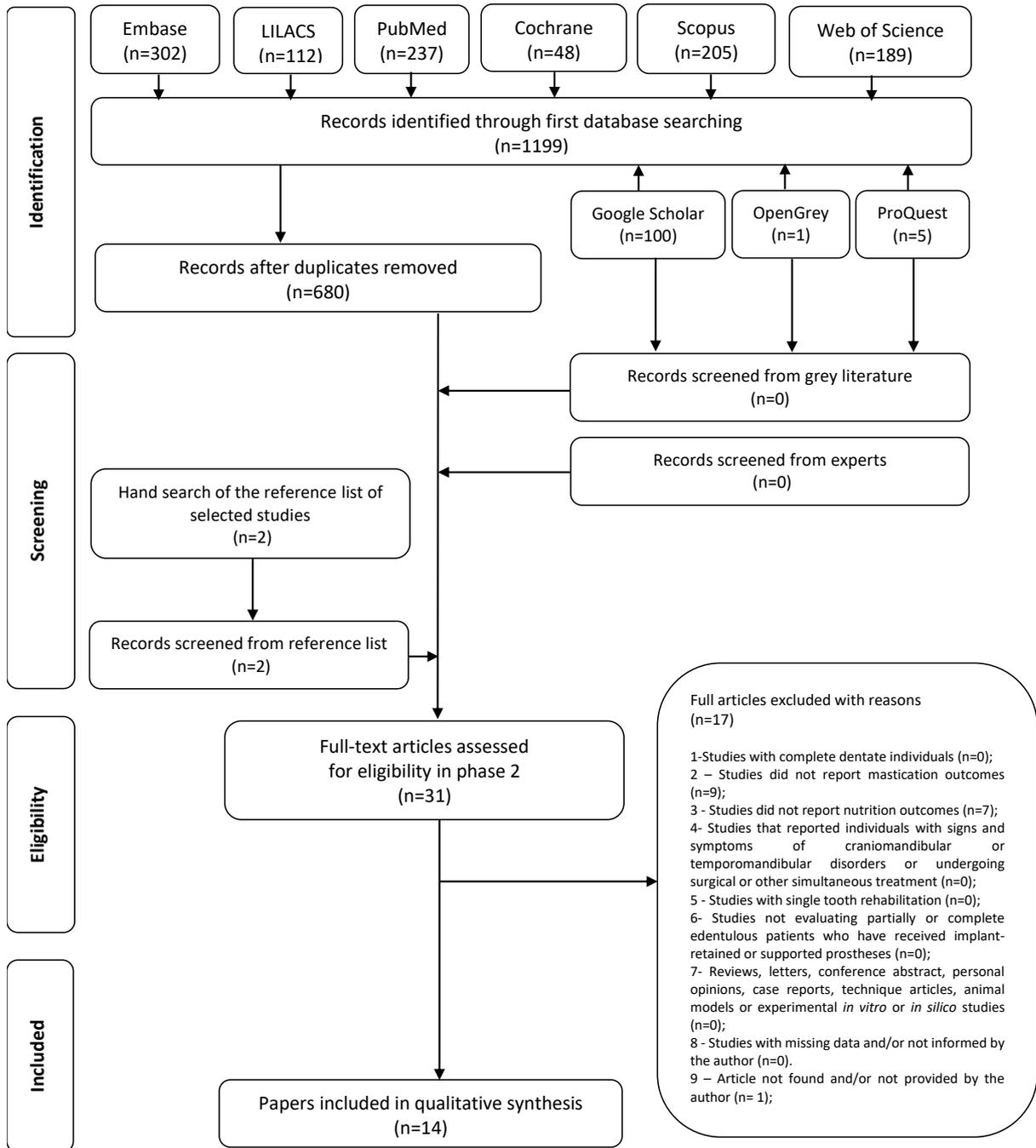


Figure 1. Flowchart of the screening process (adapted from PRISMA).



Figure 2. Summary of the risk of bias assessment for the different study designs. 2.1 Risk of bias assessment for randomized clinical trials (Cochrane Collaboration’s tool). 2.2 Risk of bias assessment for paired clinical trials (Joanna Briggs Institute Critical Appraisal Non-randomized studies (Quasi-randomized experimental studies) Checklist). 2.3. Risk of bias assessment for cohort studies (“Meta-Analysis of Statistics Assessment and Review Instrument” (JBI - MASTARI) critical appraisal tools)

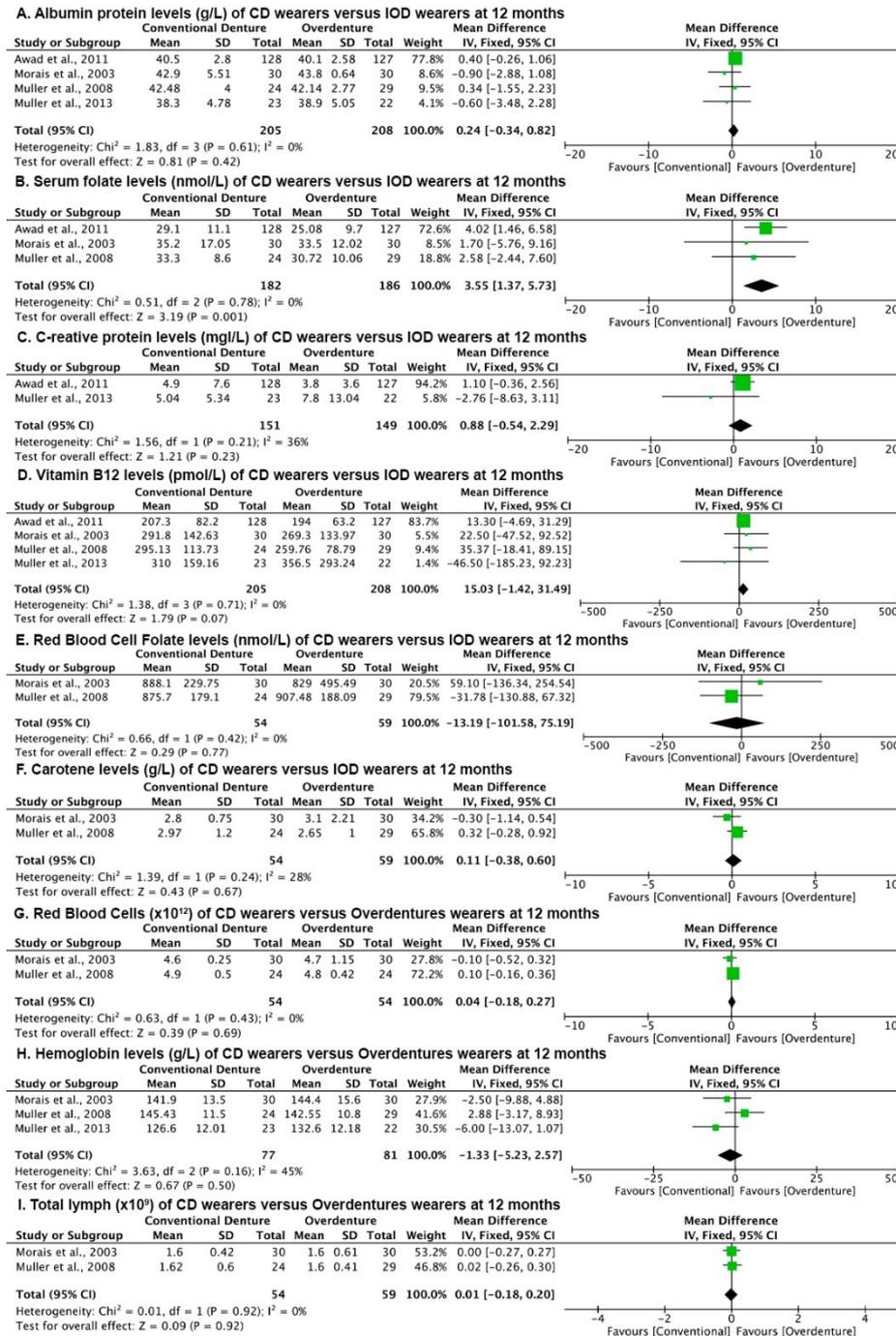


Figure 3. Forest plot evaluating the blood level of different nutrients, comparing conventional complete denture (CD) to implant overdenture (IOD) wearers after 12 months of use. A, Albumin protein levels (g/L). B, Serum folate levels (nmol/L). C, C-reactive protein levels (mg/L). D, Vitamin B12 (pmol/L). E, Red Blood Cell Folate levels (nmol/L). F, Carotene levels (g/L). G, Red Blood Cells ($\times 10^{12}$). H, Hemoglobin levels (g/L). I, Total lymph ($\times 10^9$)

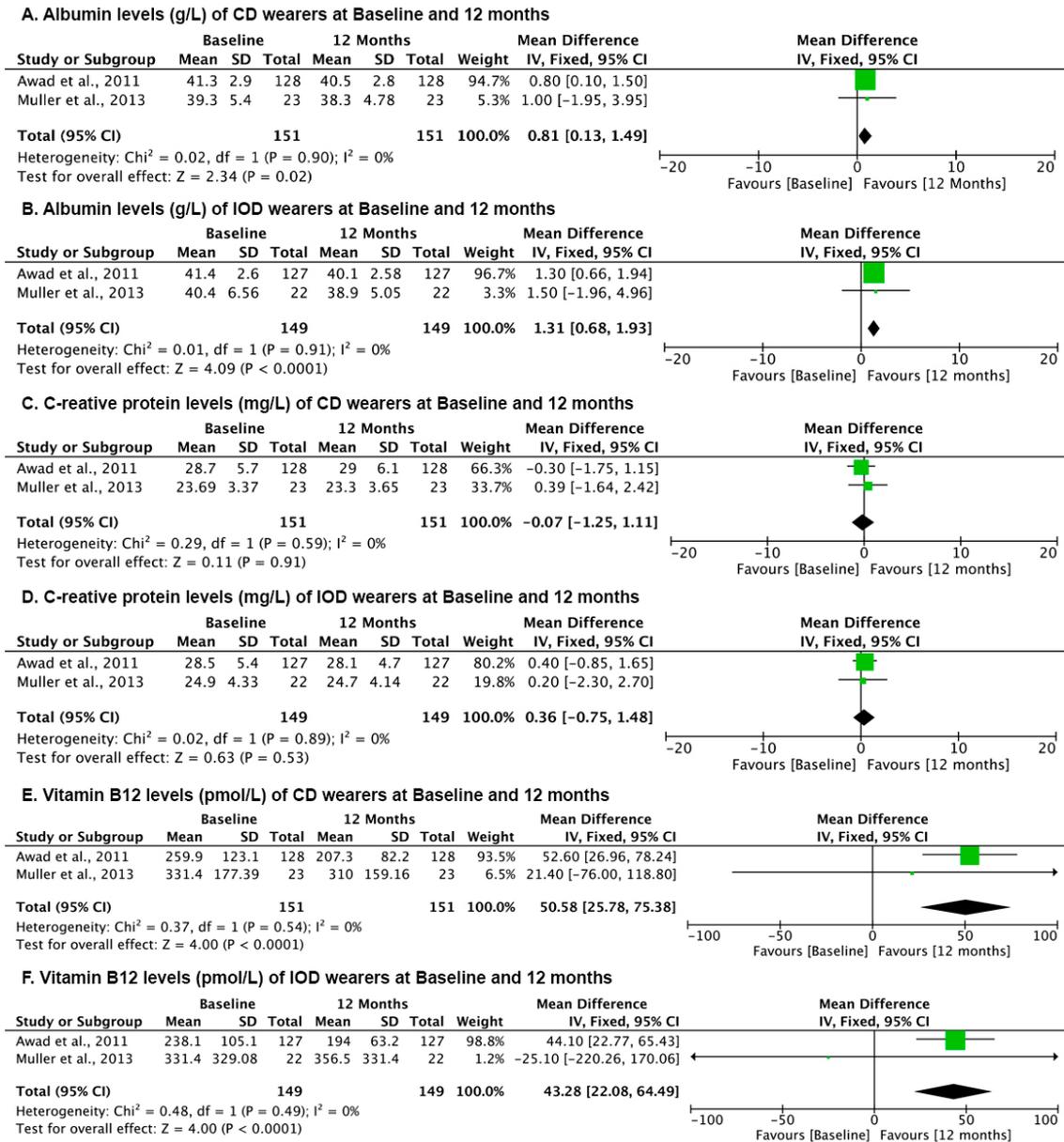
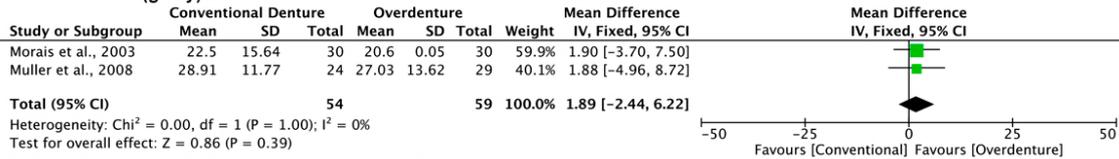
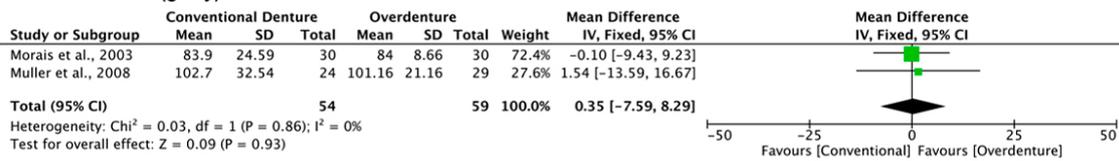


Figure 4. Forest plot evaluating the blood level of several nutrients, comparing the baseline and 12 months of use of both conventional complete dentures (CDs) and implant overdentures (IODs). A, Albumin levels (g/L) of CD wearers. B, Albumin levels (g/L) of IOD wearers. C, C-reactive protein levels (mg/L) of CD wearers. D, C-reactive protein levels (mg/L) of IOD wearers. E, Vitamin B12 (pmol/L) of CD wearers. F, Vitamin B12 (pmol/L) of IOD wearers.

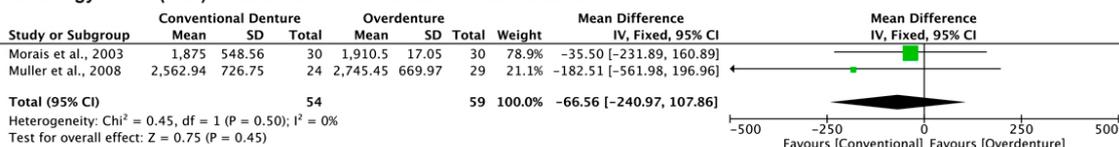
A. Fiber intake (g/day) of CD wearers versus IOD wearers at 12 months



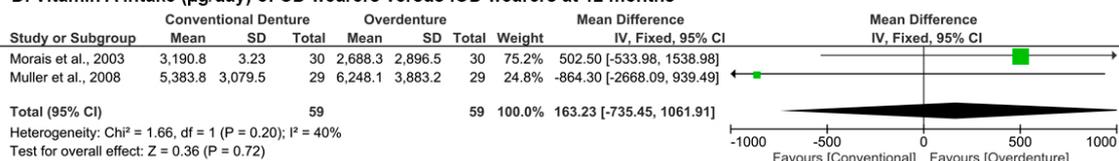
B. Protein intake (g/day) of CD wearers versus IOD wearers at 12 months



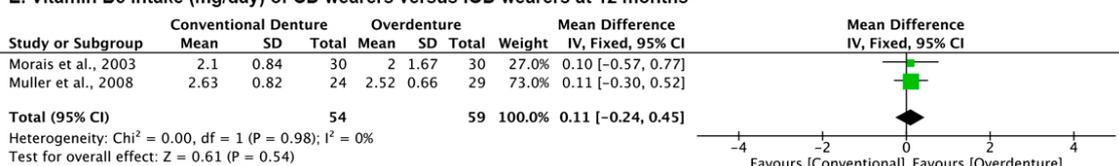
C. Energy intake (kcal) of CD wearers versus IOD wearers at 12 months



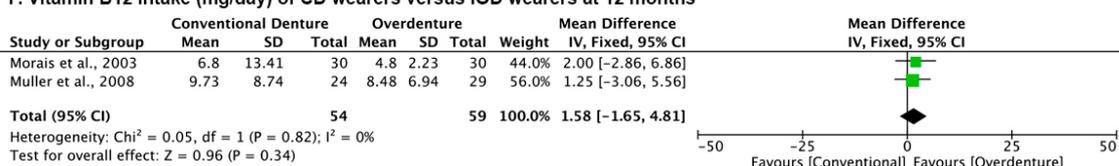
D. Vitamin A intake (µg/day) of CD wearers versus IOD wearers at 12 months



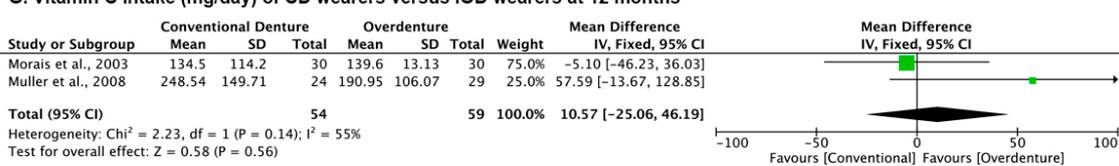
E. Vitamin B6 intake (mg/day) of CD wearers versus IOD wearers at 12 months



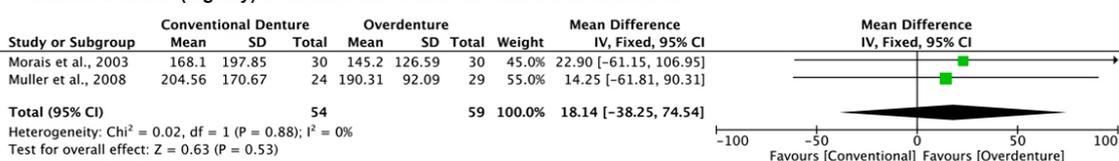
F. Vitamin B12 intake (mg/day) of CD wearers versus IOD wearers at 12 months



G. Vitamin C intake (mg/day) of CD wearers versus IOD wearers at 12 months



H. Vitamin D intake (mg/day) of CD wearers versus IOD wearers at 12 months



I. Vitamin E intake (mg/day) of CD wearers versus IOD wearers at 12 months

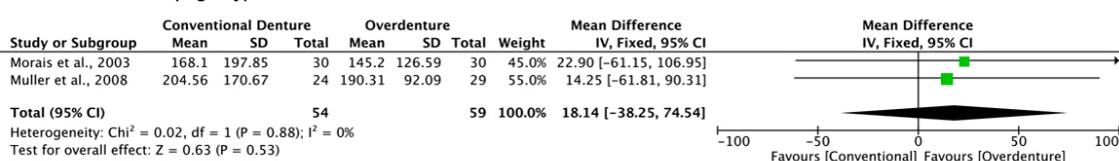


Figure 5. Forest plot evaluating the nutritional intake (dietary diary) of conventional complete dentures (CDs) wearers in comparison to implant overdentures (IODs) wearers after 12 months

of use. A, Fiber intake (g/day). B, Protein intake (g/day). C, Energy intake (kcal). D, Vitamin A intake ($\mu\text{g}/\text{day}$). E, Vitamin B6 intake (mg/day). F, Vitamin B12 intake (mg/day). G, Vitamin C intake (mg/day). H, Vitamin D intake (mg/day). I, Vitamin E intake (mg/day)

Supplemental File 1: Search Terms and Database

SEARCH TERMS AND DATABASES

DATABASE	SEARCH
----------	--------

PubMed	<p>("Dentures"[Mesh] OR "denture" OR "dentures" OR "Denture, Complete"[Mesh] OR "complete prosthesis" OR "complete prostheses" OR "Denture, Partial"[Mesh] OR "denture, partial, removable"[MeSH Terms] OR "removable prosthodontics" OR "removable prosthodontic" OR "RPD" OR "removable partial prosthesis" OR "removable partial prostheses" OR "removable denture" OR "removable dentures" OR "removable prosthesis" OR "removable prostheses" OR "detachable prosthesis" OR "bilaterally missing molars" OR "fixed bridge" OR "fixed bridges" OR "fixed partial denture" OR "fixed partial dentures" OR "fixed partial prosthesis" OR "fixed partial prostheses" OR "toronto bridge" OR "fixed rehabilitation" OR "fixed rehabilitations" OR "fixed implant-supported prosthesis" OR "fixed implant-supported prostheses" OR "fixed prosthodontic" OR "fixed prosthodontics" OR "dental prosthesis"[MeSH Terms] OR "dental prosthesis"[Title/Abstract] OR "dental prostheses"[Title/Abstract] OR "dental implants"[MeSH Terms] OR "dental implants" OR "dental implant" OR "dental implantation"[MeSH Terms] OR "dental implantation" OR "oral rehabilitation"[Title/Abstract] OR "denture, overlay"[MeSH Terms] OR "overlay denture" OR "overlay dentures" OR "overdenture" OR "overdentures" OR "implant overdenture" OR "implant overdentures" OR "prostheses and implants"[MeSH Terms] OR "prostheses and implants" OR "Dental Prosthesis, Implant-Supported"[Mesh] OR "implant-retained" OR "osseointegrated implant" OR "osseointegrated implants" OR "implant supported" OR "implant stabilized") AND ("Mastication"[Mesh] OR "mastication" OR "chewing" OR "masticatory" OR "sieving method" OR "mixing ability test" OR "biting ability" OR "biting abilities" OR "deglutition"[MeSH Terms] OR "deglutition" OR "swallowing" OR "bite force"[MeSH Terms] OR "bite force" OR "bite forces" OR "maximum occlusal force" OR "maximum occlusal forces" OR "masticatory muscles"[MeSH Terms] OR "muscle thickness" OR "masseter muscle"[MeSH Terms] OR "masseter muscle" OR "masseter thickness" OR "jaw motion" OR "chewing movement" OR "chewing movements" OR "electromyography"[MeSH Terms] OR "electromyography" OR "electromyographic activity") AND ("nutritional intake" OR "nutritional level" OR "nutrient intake" OR "nutrients intake" OR "diet questionnaires" OR "anthropometric measurement" OR "anthropometric measurements" OR "nutritional status"[MeSH Terms] OR "nutritional status" OR "nutrition"[Title/Abstract] OR "nutrition assessment"[MeSH Terms] OR "nutrition assessment" OR "nutrition assessments" OR "Nutritional Assessment" OR "nutritional assessments" OR "nutrition index" OR "nutrition indexes" OR "prognostic nutritional index" OR "mini nutritional assessment" OR "mini nutritional assessments" OR "malnutrition"[MeSH Terms] OR "malnutrition" OR "Nutritional Deficiency" OR "Nutritional Deficiencies" OR "Undernutrition" OR "Malnourishment")</p>
--------	--

SCOPUS TITLE-ABS-KEY("denture" OR "dentures" OR "complete prosthesis" OR "complete prostheses" OR "removable prosthodontics" OR "removable prosthodontic" OR "RPD" OR "removable partial prosthesis" OR "removable partial prostheses" OR "removable prosthesis" OR "removable prostheses" OR "detachable prosthesis" OR "bilaterally missing molars" OR "fixed bridge" OR "fixed bridges" OR "fixed partial prosthesis" OR "fixed partial prostheses" OR "toronto bridge" OR "fixed rehabilitation" OR "fixed rehabilitations" OR "fixed implant-supported prosthesis" OR "fixed implant-supported prostheses" OR "fixed prosthodontic" OR "fixed prosthodontics" OR "dental prosthesis" OR "dental prostheses" OR "dental implants" OR "dental implant" OR "dental implantation" OR "oral rehabilitation" OR "overlay denture" OR "overlay dentures" OR "overdenture" OR "overdentures" OR "prostheses and implants" OR "implant-retained" OR "osseointegrated implant" OR "osseointegrated implants" OR "implant supported" OR "implant stabilized") AND TITLE-ABS-KEY("mastication" OR "chewing" OR "masticatory" OR "sieving method" OR "mixing ability test" OR "biting ability" OR "biting abilities" OR "deglutition" OR "swallowing" OR "bite force" OR "bite forces" OR "maximum occlusal force" OR "maximum occlusal forces" OR "muscle thickness" OR "masseter muscle" OR "masseter thickness" OR "jaw motion" OR "chewing movement" OR "chewing movements" OR "electromyography" OR "electromyographic activity") AND TITLE-ABS-KEY("nutritional intake" OR "nutritional level" OR "nutrient intake" OR "nutrients intake" OR "diet questionnaires" OR "anthropometric measurement" OR "anthropometric measurements" OR "nutritional status" OR "nutrition" OR "Nutritional Assessment" OR "nutritional assessments" OR "prognostic nutritional index" OR "mini nutritional assessment" OR "mini nutritional assessments" OR "malnutrition" OR "Nutritional Deficiency" OR "Nutritional Deficiencies" OR "Undernutrition" OR "Malnourishment" OR "Malnourishments") AND (LIMIT-TO (DOCTYPE,"ar"))

Web of Science of ("denture" OR "dentures" OR "complete prosthesis" OR "complete prostheses" OR "removable prosthodontics" OR "removable prosthodontic" OR "RPD" OR "removable partial prosthesis" OR "removable partial prostheses" OR "removable prosthesis" OR "removable prostheses" OR "detachable prosthesis" OR "bilaterally missing molars" OR "fixed bridge" OR "fixed bridges" OR "fixed partial prosthesis" OR "fixed partial prostheses" OR "toronto bridge" OR "fixed rehabilitation" OR "fixed rehabilitations" OR "fixed implant-supported prosthesis" OR "fixed implant-supported prostheses" OR "fixed prosthodontic" OR "fixed prosthodontics" OR "dental prosthesis" OR "dental prostheses" OR "dental implants" OR "dental implant" OR "dental implantation" OR "oral rehabilitation" OR "overlay denture" OR "overlay dentures" OR "overdenture" OR "overdentures" OR "prostheses and implants" OR "implant-retained" OR "osseointegrated implant" OR "osseointegrated implants" OR "implant supported" OR "implant stabilized") AND ("mastication" OR "chewing" OR "masticatory" OR "sieving method" OR "mixing ability test" OR "biting ability" OR "biting abilities" OR "deglutition" OR "swallowing" OR "bite force" OR "bite forces" OR "maximum occlusal force" OR "maximum occlusal forces" OR "muscle thickness" OR "masseter muscle" OR "masseter thickness" OR "jaw motion" OR "chewing movement" OR "chewing movements" OR "electromyography" OR "electromyographic activity") AND ("nutritional intake" OR "nutritional level" OR "nutrient intake" OR "nutrients intake" OR "diet questionnaires" OR "anthropometric measurement" OR "anthropometric measurements" OR "nutritional status" OR "nutrition" OR "Nutritional Assessment" OR "nutritional assessments" OR "prognostic nutritional index" OR "mini nutritional assessment" OR "mini nutritional assessments" OR "malnutrition" OR "Nutritional Deficiency" OR "Nutritional Deficiencies" OR "Undernutrition" OR "Malnourishment" OR "Malnourishments")

Cochrane	("denture" OR "dentures" OR "complete prosthesis" OR "complete prostheses" OR "removable prosthodontics" OR "removable prosthodontic" OR "RPD" OR "removable partial prosthesis" OR "removable partial prostheses" OR "removable prosthesis" OR "removable prostheses" OR "detachable prosthesis" OR "bilaterally missing molars" OR "fixed bridge" OR "fixed bridges" OR "fixed partial prosthesis" OR "fixed partial prostheses" OR "toronto bridge" OR "fixed rehabilitation" OR "fixed rehabilitations" OR "fixed implant-supported prosthesis" OR "fixed implant-supported prostheses" OR "fixed prosthodontic" OR "fixed prosthodontics" OR "dental prosthesis" OR "dental prostheses" OR "dental implants" OR "dental implant" OR "dental implantation" OR "oral rehabilitation" OR "overlay denture" OR "overlay dentures" OR "overdenture" OR "overdentures" OR "prostheses and implants" OR "implant-retained" OR "osseointegrated implant" OR "osseointegrated implants" OR "implant supported" OR "implant stabilized") AND ("mastication" OR "chewing" OR "masticatory" OR "sieving method" OR "mixing ability test" OR "biting ability" OR "biting abilities" OR "deglutition" OR "swallowing" OR "bite force" OR "bite forces" OR "maximum occlusal force" OR "maximum occlusal forces" OR "muscle thickness" OR "masseter muscle" OR "masseter thickness" OR "jaw motion" OR "chewing movement" OR "chewing movements" OR "electromyography" OR "electromyographic activity") AND ("nutritional intake" OR "nutritional level" OR "nutrient intake" OR "nutrients intake" OR "diet questionnaires" OR "anthropometric measurement" OR "anthropometric measurements" OR "nutritional status" OR "nutrition" OR "Nutritional Assessment" OR "nutritional assessments" OR "prognostic nutritional index" OR "mini nutritional assessment" OR "mini nutritional assessments" OR "malnutrition" OR "Nutritional Deficiency" OR "Nutritional Deficiencies" OR "Undernutrition" OR "Malnourishment" OR "Malnourishments")
EMBASE	("denture" OR "dentures" OR "complete prosthesis" OR "complete prostheses" OR "removable prosthodontics" OR "removable prosthodontic" OR "RPD" OR "removable partial prosthesis" OR "removable partial prostheses" OR "removable prosthesis" OR "removable prostheses" OR "detachable prosthesis" OR "bilaterally missing molars" OR "fixed bridge" OR "fixed bridges" OR "fixed partial prosthesis" OR "fixed partial prostheses" OR "toronto bridge" OR "fixed rehabilitation" OR "fixed rehabilitations" OR "fixed implant-supported prosthesis" OR "fixed implant-supported prostheses" OR "fixed prosthodontic" OR "fixed prosthodontics" OR "dental prosthesis" OR "dental prostheses" OR "dental implants" OR "dental implant" OR "dental implantation" OR "oral rehabilitation" OR "overlay denture" OR "overlay dentures" OR "overdenture" OR "overdentures" OR "prostheses and implants" OR "implant-retained" OR "osseointegrated implant" OR "osseointegrated implants" OR "implant supported" OR "implant stabilized") AND ("mastication" OR "chewing" OR "masticatory" OR "sieving method" OR "mixing ability test" OR "biting ability" OR "biting abilities" OR "deglutition" OR "swallowing" OR "bite force" OR "bite forces" OR "maximum occlusal force" OR "maximum occlusal forces" OR "muscle thickness" OR "masseter muscle" OR "masseter thickness" OR "jaw motion" OR "chewing movement" OR "chewing movements" OR "electromyography" OR "electromyographic activity") AND ("nutritional intake" OR "nutritional level" OR "nutrient intake" OR "nutrients intake" OR "diet questionnaires" OR "anthropometric measurement" OR "anthropometric measurements" OR "nutritional status" OR "nutrition" OR "Nutritional Assessment" OR "nutritional assessments" OR "prognostic nutritional index" OR "mini nutritional assessment" OR "mini nutritional assessments" OR "malnutrition" OR "Nutritional Deficiency" OR "Nutritional Deficiencies" OR "Undernutrition" OR "Malnourishment" OR "Malnourishments")

LILACS (tw:(denture* OR prosthesis* OR prosthodontic* OR "RPD" OR "bilaterally missing molars" OR "fixed bridge" OR "fixed bridges" OR "toronto bridge" OR rehabilitation* OR overdenture* OR "dental implantation" OR implant* OR dentadura* OR prótese* OR "PPR" OR "molares perdidos bilateralmente" OR "ponte fixa" OR "pontes fixas" OR reabilitac* OR sobredentadura* OR "implantação dental" OR protesis OR "ponte fija" OR "pontes fijas" OR rehabilitación* OR "implantación dental")) AND (tw:(mastica* OR "chewing" OR "sieving method" OR "mixing ability test" OR "biting" OR "bite" OR degluti* OR "swallowing" OR "occlusal force" OR "occlusal forces" OR "muscle thickness" OR "masseter" OR "jaw motion" OR "electromyography" OR mastiga* OR "método de peneiramento" OR "teste de habilidade de mistura" OR mordida* OR "força oclusal" OR "espessura muscular" OR "movimento mandibular" OR electromiografi* OR "método de cribado" OR "fuerza oclusal" OR "espesor muscular" OR "masetero" OR "movimiento mandibular" OR eletromiografi*)) AND (tw:(nutrition* OR nutrient* OR diet* OR "anthropometric" OR "malnutrition" OR "Undernutrition" OR "Malnourishment" OR "Malnourishments" OR "nutrição" OR antropometri* OR "desnutrição" OR nutricion* OR "desnutricion")) AND (instance:"regional") AND (db:("LILACS") AND type:("article"))

ProQuest NOFT(("denture" OR "dentures" OR "complete prosthesis" OR "complete prostheses" OR "removable prosthodontics" OR "removable prosthodontic" OR "RPD" OR "removable partial prosthesis" OR "removable partial prostheses" OR "removable prosthesis" OR "removable prostheses" OR "detachable prosthesis" OR "bilaterally missing molars" OR "fixed bridge" OR "fixed bridges" OR "fixed partial prosthesis" OR "fixed partial prostheses" OR "toronto bridge" OR "fixed rehabilitation" OR "fixed rehabilitations" OR "fixed implant-supported prosthesis" OR "fixed implant-supported prostheses" OR "fixed prosthodontic" OR "fixed prosthodontics" OR "dental prosthesis" OR "dental prostheses" OR "dental implants" OR "dental implant" OR "dental implantation" OR "oral rehabilitation" OR "overlay denture" OR "overlay dentures" OR "overdenture" OR "overdentures" OR "prostheses and implants" OR "implant-retained" OR "osseointegrated implant" OR "osseointegrated implants" OR "implant supported" OR "implant stabilized") AND ("mastication" OR "chewing" OR "masticatory" OR "sieving method" OR "mixing ability test" OR "biting ability" OR "biting abilities" OR "deglutition" OR "swallowing" OR "bite force" OR "bite forces" OR "maximum occlusal force" OR "maximum occlusal forces" OR "muscle thickness" OR "masseter muscle" OR "masseter thickness" OR "jaw motion" OR "chewing movement" OR "chewing movements" OR "electromyography" OR "electromyographic activity") AND ("nutritional intake" OR "nutritional level" OR "nutrient intake" OR "nutrients intake" OR "diet questionnaires" OR "anthropometric measurement" OR "anthropometric measurements" OR "nutritional status" OR "nutrition" OR "Nutritional Assessment" OR "nutritional assessments" OR "prognostic nutritional index" OR "mini nutritional assessment" OR "mini nutritional assessments" OR "malnutrition" OR "Nutritional Deficiency" OR "Nutritional Deficiencies" OR "Undernutrition" OR "Malnourishment" OR "Malnourishments"))

OpenGrey ("denture" OR "dentures" OR "complete prosthesis" OR "complete prostheses" OR "removable prosthodontics" OR "removable prosthodontic" OR "RPD" OR "removable partial prosthesis" OR "removable partial prostheses" OR "removable prosthesis" OR "removable prostheses" OR "detachable prosthesis" OR "bilaterally missing molars" OR "fixed bridge" OR "fixed bridges" OR "fixed partial prosthesis" OR "fixed partial prostheses" OR "toronto bridge" OR "fixed rehabilitation" OR "fixed rehabilitations" OR "fixed implant-supported prosthesis" OR "fixed implant-supported prostheses" OR "fixed prosthodontic" OR "fixed prosthodontics" OR "dental prosthesis" OR "dental prostheses" OR "dental implants" OR "dental implant" OR "dental implantation" OR "oral rehabilitation" OR "overlay denture" OR "overlay dentures" OR "overdenture" OR "overdentures" OR "prostheses and implants" OR "implant-retained"

OR "osseointegrated implant" OR "osseointegrated implants" OR "implant supported" OR "implant stabilized") AND ("mastication" OR "chewing" OR "masticatory" OR "sieving method" OR "mixing ability test" OR "biting ability" OR "biting abilities" OR "deglutition" OR "swallowing" OR "bite force" OR "bite forces" OR "maximum occlusal force" OR "maximum occlusal forces" OR "muscle thickness" OR "masseter muscle" OR "masseter thickness" OR "jaw motion" OR "chewing movement" OR "chewing movements" OR "electromyography" OR "electromyographic activity") AND ("nutritional intake" OR "nutritional level" OR "nutrient intake" OR "nutrients intake" OR "diet questionnaires" OR "anthropometric measurement" OR "anthropometric measurements" OR "nutritional status" OR "nutrition" OR "Nutritional Assessment" OR "nutritional assessments" OR "prognostic nutritional index" OR "mini nutritional assessment" OR "mini nutritional assessments" OR "malnutrition" OR "Nutritional Deficiency" OR "Nutritional Deficiencies" OR "Undernutrition" OR "Malnourishment" OR "Malnourishments")

Google ("denture" OR "dentures" OR "removable partial prosthesis" OR "fixed partial prosthesis" OR
Scholar "dental prosthesis" OR "dental implants" OR "overdenture") AND ("mastication" OR "masticatory") AND ("nutritional intake" OR "nutrition" OR "malnutrition")

Supplemental File 2: Articles excluded and reasons for exclusion.

Author, year	Reasons for exclusion*
1. Batisse et al, 2016	3
2. Berretin-Felix et al, 2008	3
3. Carletti et al, 2019	2
4. El osta et al, 2017	2
5. Ellis et al, 2008	2
6. Ellis et al, 2010	2
7. Hamdan et al, 2013	2
8. Khoury-Ribas et al, 2019	3
9. Linden et al, 2011	2
10. Neto et al, 2012	3
11. Oliveira et al, 2005	9
12. Sandstrom et al, 1987	2
13. Shimmel et al, 2013	3
14. Tajbakhsh et al, 2013	2
15. Tanasic et al, 2017	2
16. Witter et al, 2013	3
17. Wolfart et al, 2016	3

*1-Studies with complete dentate individuals (n=0); 2 – Studies did not report mastication outcomes (n=9); 3 - Studies did not report nutrition outcomes (n=7); 4- Studies that reported individuals with signs and symptoms of craniomandibular or temporomandibular disorders or undergoing surgical or other simultaneous treatment (n=0); 5 - Studies with single tooth rehabilitation (n=0); 6- Studies not evaluating partially or complete edentulous patients who have received implant-retained or supported prostheses (n=0); 7- Reviews, letters, conference abstract, personal opinions, case reports, technique articles, animal models or experimental in vitro or in silico studies (n=0); 8 - Studies with missing data and/or not informed by the author (n=0).9 – Article not found and/or not provided by the author (n= 1).

Supplemental File 3: Summary of Findings Tables (GRADEpro GDT; the GRADE Working Group).

Summary of findings:

Blood level of different nutrients, comparing conventional complete denture (CD) to implant overdenture (IOD) wearers after 12 months of use.

Patient or population: patient's serum nutrient levels at 12 months

Setting:

Intervention: Implant Prosthesis

Comparison: Conventional Prosthesis

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	No of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with Conventional Prosthesis	Risk with Implant Prosthesis				
Albumin	The mean albumin ranged from 38.3 to 42.9 g/L	MD 0.24 g/L more (0.34 fewer to 0.82 more)	-	413 (4 RCTs)	⊕⊕○○ LOW ^a	
Serum Folate	The mean serum Folate ranged from 29.1 to 35.2 nmol/L	MD 3.55 nmol/L more (1.37 more to 5.73 more)	-	368 (3 RCTs)	⊕○○○ VERY LOW ^{a,b}	
C-reactive Protein	The mean c-reactive Protein ranged from 4.9 to 5.04 mg/L	MD 0.88 mg/L higher (0.54 lower to 2.29 higher)	-	300 (2 RCTs)	⊕○○○ VERY LOW ^b	
Vitamin B12	The mean vitamin B12 ranged from 207.3 to 310 pmol/L	MD 15.03 pmol/L more (1.42 fewer to 31.49 more)	-	413 (4 RCTs)	⊕⊕○○ LOW ^a	
RBC Folate	The mean RBC Folate ranged from 875.7 to 888.1 nmol/L	MD 13.19 nmol/L lower (101.58 lower to 75.19 higher)	-	113 (2 RCTs)	⊕○○○ VERY LOW ^{a,b}	
Carotene	The mean carotene ranged from 2.8 to 2.97 g/L	MD 0.11 g/L higher (0.38 lower to 0.6 higher)	-	113 (2 RCTs)	⊕○○○ VERY LOW ^{a,b}	
RBC	The mean RBC ranged from 4.6 to 4.9 x 10 ¹²	MD 0.04 x 10¹² higher (0.18 lower to 0.27 higher)	-	108 (2 RCTs)	⊕○○○ VERY LOW ^{a,b}	

Summary of findings:

Blood level of different nutrients, comparing conventional complete denture (CD) to implant overdenture (IOD) wearers after 12 months of use.

Patient or population: patient's serum nutrient levels at 12 months

Setting:

Intervention: Implant Prosthesis

Comparison: Conventional Prosthesis

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	No of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with Conventional Prosthesis	Risk with Implant Prosthesis				
Hemoglobin	The mean hemoglobin ranged from 126.6 to 145.43 g/L	MD 1.33 g/L lower (5.23 lower to 2.57 higher)	-	158 (3 RCTs)	⊕○○○ VERY LOW ^{a,b}	
Total Lymph	The mean total Lymph ranged from 1.6 to 1.62 x 10 ⁹	MD 0.01 x 10⁹ higher (0.18 lower to 0.2 higher)	-	113 (2 RCTs)	⊕○○○ VERY LOW ^{a,b}	

*The risk in the intervention group (and its 95% confidence interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI).

CI: Confidence interval; MD: Mean difference

GRADE Working Group grades of evidence**High certainty:** We are very confident that the true effect lies close to that of the estimate of the effect**Moderate certainty:** We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different**Low certainty:** Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect**Very low certainty:** We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect**Explanations**

a. High Risk of Bias on two domains

b. Small sample size (Less than 400 participants.)

Summary of findings:

Blood level of several nutrients, comparing the baseline and 12 months of use of both conventional complete dentures (CDs) and implant overdentures (IODs).

Patient or population: nutrient serum levels improvement

Setting:

Intervention: Implant rehabilitation

Comparison: conventional rehabilitation

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	No of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with conventional rehabilitation	Risk with Implant rehabilitation				
Albumin CD wearers	The mean albumin CD wearers ranged from 39.3 to 41.3 g/L	MD 0.81 g/L higher (0.13 higher to 1.49 higher)	-	302 (2 RCTs)	⊕⊕○○ LOW ^{a,b}	
Albumin IOD wearers	The mean albumin IOD wearers ranged from 40.4 to 41.4 g/L	MD 1.31 g/L higher (0.68 higher to 1.93 higher)	-	298 (2 RCTs)	⊕⊕○○ LOW ^{a,b}	
C-reactive protein CD wearers	The mean c-reactive protein CD wearers ranged from 23.69 to 28.7 mg/L	MD 0.07 mg/L lower (1.25 lower to 1.11 higher)	-	302 (2 RCTs)	⊕⊕○○ LOW ^{a,b}	
C-reactive protein IOD wearers	The mean c-reactive protein IOD wearers ranged from 24.9 to 28.5 mg/L	MD 0.36 mg/L higher (0.75 higher to 1.48 higher)	-	298 (2 RCTs)	⊕⊕○○ LOW ^{a,b}	
Vitamin B12 CD wearers	The mean vitamin B12 CD wearers ranged from 259.9 to 331.4 pmol/L	MD 50.58 pmol/L higher (25.78 higher to 75.38 higher)	-	302 (2 RCTs)	⊕⊕○○ LOW ^{a,b}	
Vitamin B12 IOD wearers	The mean vitamin B12 IOD wearers ranged from 238.1 to 331.4 pmol/L	MD 43.28 pmol/L higher (22.08 higher to 64.49 higher)	-	298 (2 RCTs)	⊕⊕○○ LOW ^{a,b}	

*The risk in the intervention group (and its 95% confidence interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI).

CI: Confidence interval; MD: Mean difference

Summary of findings:

Blood level of several nutrients, comparing the baseline and 12 months of use of both conventional complete dentures (CDs) and implant overdentures (IODs).

Patient or population: nutrient serum levels improvement

Setting:

Intervention: Implant rehabilitation

Comparison: conventional rehabilitation

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	No of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with conventional rehabilitation	Risk with Implant rehabilitation				

GRADE Working Group grades of evidence

High certainty: We are very confident that the true effect lies close to that of the estimate of the effect

Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different

Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect

Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Explanations

- a. High Risk of Bias on two domains
- b. Small sample size (Less than 400 participants.)

Summary of findings:

Nutritional intake (dietary diary) of conventional complete dentures (CDs) wearers in comparison to implant overdentures (IODs) wearers after 12 months of use.
Patient or population: nutrient intake improvement at 12 months

Setting:
Intervention: Implant Prosthesis

Comparison: Conventional Prosthesis

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	Ne of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with Conventional Prosthesis	Risk with Implant Prosthesis				
Fiber Intake	The mean fiber Intake ranged from 22.5 to 28.91 g/day	MD 1.89 g/day higher (2.44 lower to 6.22 higher)	-	113 (2 RCTs)	⊕○○○ VERY LOW ^{a,b}	
Protein Intake	The mean protein Intake ranged from 83.9 to 102.7 g/day	MD 0.35 g/day higher (7.59 lower to 8.29 higher)	-	113 (2 RCTs)	⊕○○○ VERY LOW ^{a,b}	
Vitamin B3 intake	The mean vitamin B3 intake ranged from 24 to 46.69 mg/day	MD 0.57 mg/day higher (3.05 lower to 4.18 higher)	-	113 (2 RCTs)	⊕○○○ VERY LOW ^{a,b}	
Vitamin B12 intake	The mean vitamin B12 intake ranged from 6.8 to 9.73 mg/day	MD 1.58 mg/day higher (1.65 lower to 4.81 higher)	-	113 (2 RCTs)	⊕○○○ VERY LOW ^{a,b}	
Vitamin E intake	The mean vitamin E intake ranged from 12.8 to 18.51 mg/day	MD 0.75 mg/day higher (0.21 lower to 1.71 higher)	-	113 (2 RCTs)	⊕○○○ VERY LOW ^{a,b}	
Vitamin C intake	The mean vitamin C intake ranged from 248.54 to 134.5 mg/day	MD 10.57 mg/day higher (25.06 lower to 46.19 higher)	-	113 (2 RCTs)	⊕○○○ VERY LOW ^{a,b}	
Vitamin D	The mean vitamin D ranged from 108.1 to 204.6 mg/day	MD 18.14 mg/day higher (38.25 lower to 74.54 higher)	-	113 (2 RCTs)	⊕○○○ VERY LOW ^{a,b}	

Summary of findings:

Nutritional intake (dietary diary) of conventional complete dentures (CDs) wearers in comparison to implant overdentures (IODs) wearers after 12 months of use.

Patient or population: nutrient intake improvement at 12 months

Setting:

Intervention: Implant Prosthesis

Comparison: Conventional Prosthesis

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	No of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with Conventional Prosthesis	Risk with Implant Prosthesis				
Vitamin B1	The mean vitamin B1 ranged from 1.6 to 1.96 mg/day	MD 0.09 mg/day lower (0.31 lower to 0.13 higher)	-	113 (2 RCTs)	⊕○○○ VERY LOW ^{a,b}	
Vitamin B2	The mean vitamin B2 ranged from 2.1 to 2.56 mg/day	MD 0.08 mg/day higher (0.27 lower to 0.43 higher)	-	113 (2 RCTs)	⊕○○○ VERY LOW ^{a,b}	
Vitamin B6	The mean vitamin B6 ranged from 2.1 to 2.63 mg/day	MD 0.11 mg/day higher (0.24 lower to 0.45 higher)	-	113 (2 RCTs)	⊕○○○ VERY LOW ^{a,b}	

*The risk in the intervention group (and its 95% confidence interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI).

CI: Confidence interval; MD: Mean difference

GRADE Working Group grades of evidence

High certainty: We are very confident that the true effect lies close to that of the estimate of the effect

Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different

Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect

Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Explanations

- a. High Risk of Bias on two domains
- b. Small sample size (Less than 400 participants.)

4 CONCLUSÃO

Apesar da reabilitação com implantes aumentar a capacidade mastigatória, o estado nutricional de pacientes, total e parcialmente edêntulos, parece ser pouco afetado, principalmente quando o nível sérico dos nutrientes é analisado. Mudanças significativas dos hábitos nutricionais não dependem apenas da capacidade mastigatória do indivíduo e sim de uma ação multidisciplinar com acompanhamento nutricional. Embora apenas estudos primários avaliando simultaneamente nutrição e mastigação tenham sido incluídos, a relação de causa-efeito entre esses parâmetros não foi avaliada, dificultando estabelecer uma relação direta entre esses fatores.

REFERÊNCIAS

- AGARWAL, E.; MILLER, M.; YAXLEY, A.; ISENRING, E. Malnutrition in the elderly: a narrative review. **Maturitas**, 76, n. 4, p. 296-302, Dec 2013.
- AHMED, T.; HABOUBI, N. Assessment and management of nutrition in older people and its importance to health. **Clin Interv Aging**, 5, p. 207-216, Aug 9 2010.
- ALLEN, F.; MCMILLAN, A. Food selection and perceptions of chewing ability following provision of implant and conventional prostheses in complete denture wearers. **Clin Oral Implants Res**, 13, n. 3, p. 320-326, Jun 2002.
- AUNE, D.; GIOVANNUCCI, E.; BOFFETTA, P.; FADNES, L. T. *et al.* Fruit and vegetable intake and the risk of cardiovascular disease, total cancer and all-cause mortality-a systematic review and dose-response meta-analysis of prospective studies. **Int J Epidemiol**, 46, n. 3, p. 1029-1056, Jun 1 2017.
- AWAD, M. A.; MORAIS, J. A.; WOLLIN, S.; KHALIL, A. *et al.* Implant overdentures and nutrition: a randomized controlled trial. **J Dent Res**, 91, n. 1, p. 39-46, Jan 2012.
- BOVEN, G. C.; RAGHOEBAR, G. M.; VISSINK, A.; MEIJER, H. J. Improving masticatory performance, bite force, nutritional state and patient's satisfaction with implant overdentures: a systematic review of the literature. **J Oral Rehabil**, 42, n. 3, p. 220-233, Mar 2015.
- CAMPOS, C. H.; GONCALVES, T. M.; RODRIGUES GARCIA, R. C. Implant retainers for free-end removable partial dentures affect mastication and nutrient intake. **Clin Oral Implants Res**, 25, n. 8, p. 957-961, Aug 2014.
- DE OLIVEIRA, T. R.; FRIGERIO, M. L. Association between nutrition and the prosthetic condition in edentulous elderly. **Gerodontology**, 21, n. 4, p. 205-208, Dec 2004.
- FONTIJN-TEKAMP, F. A.; VAN DER BILT, A.; ABBINK, J. H.; BOSMAN, F. Swallowing threshold and masticatory performance in dentate adults. **Physiol Behav**, 83, n. 3, p. 431-436, Dec 15 2004.
- GAEWKHIEW, P.; SABBAH, W.; BERNABE, E. Does tooth loss affect dietary intake and nutritional status? A systematic review of longitudinal studies. **J Dent**, 67, p. 1-8, Dec 2017.
- GJENGEDAL, H.; DAHL, L.; LAVIK, A.; TROVIK, T. A. *et al.* Randomized clinical trial comparing dietary intake in patients with implant-retained overdentures and conventionally relined denture. **Int J Prosthodont**, 25, n. 4, p. 340-347, Jul-Aug 2012.
- GLABSKA, D.; GUZEK, D.; GROELE, B.; GUTKOWSKA, K. Fruit and Vegetable Intake and Mental Health in Adults: A Systematic Review. **Nutrients**, 12, n. 1, Jan 1 2020.
- GONCALVES, T. M.; CAMPOS, C. H.; GARCIA, R. C. Effects of implant-based prostheses on mastication, nutritional intake, and oral health-related quality of life in partially edentulous

patients: a paired clinical trial. **Int J Oral Maxillofac Implants**, 30, n. 2, p. 391-396, Mar-Apr 2015.

HERNANDEZ MORANTE, J. J.; GOMEZ MARTINEZ, C.; MORILLAS-RUIZ, J. M. Dietary Factors Associated with Frailty in Old Adults: A Review of Nutritional Interventions to Prevent Frailty Development. **Nutrients**, 11, n. 1, Jan 5 2019.

HUTTON, B.; FEINE, J.; MORAIS, J. Is there an association between edentulism and nutritional state? **J Can Dent Assoc**, 68, n. 3, p. 182-187, Mar 2002.

IWASAKI, M.; TAYLOR, G. W.; MANZ, M. C.; YOSHIHARA, A. *et al.* Oral health status: relationship to nutrient and food intake among 80-year-old Japanese adults. **Community Dent Oral Epidemiol**, 42, n. 5, p. 441-450, Oct 2014.

JAUHAINEN, L.; MANNISTO, S.; YLOSTALO, P.; VEHKALAHTI, M. *et al.* Food Consumption and Nutrient Intake in Relation to Denture Use in 55- to 84-Year-Old Men and Women -Results of a Population Based Survey. **J Nutr Health Aging**, 21, n. 5, p. 492-500, 2017.

KOKA, S.; GUPTA, A. Association between missing tooth count and mortality: A systematic review. **J Prosthodont Res**, 62, n. 2, p. 134-151, Apr 2018.

KOSSIONI, A. E. The Association of Poor Oral Health Parameters with Malnutrition in Older Adults: A Review Considering the Potential Implications for Cognitive Impairment. **Nutrients**, 10, n. 11, Nov 8 2018.

KRAUSCH-HOFMANN, S.; CUYPERS, L.; IVANOVA, A.; DUYCK, J. Predictors of Patient Satisfaction with Removable Denture Renewal: A Pilot Study. **J Prosthodont**, 27, n. 6, p. 509-516, Jul 2018.

MARSHALL, T. A.; WARREN, J. J.; HAND, J. S.; XIE, X. J. *et al.* Oral health, nutrient intake and dietary quality in the very old. **J Am Dent Assoc**, 133, n. 10, p. 1369-1379, Oct 2002.

MORAIS, J. A.; HEYDECKE, G.; PAWLIUK, J.; LUND, J. P. *et al.* The effects of mandibular two-implant overdentures on nutrition in elderly edentulous individuals. **J Dent Res**, 82, n. 1, p. 53-58, Jan 2003.

MULLER, F.; DUVERNAY, E.; LOUP, A.; VAZQUEZ, L. *et al.* Implant-supported mandibular overdentures in very old adults: a randomized controlled trial. **J Dent Res**, 92, n. 12 Suppl, p. 154S-160S, Dec 2013.

N'GOM P, I.; WODA, A. Influence of impaired mastication on nutrition. **J Prosthet Dent**, 87, n. 6, p. 667-673, Jun 2002.

SHINKAI, R. S.; HATCH, J. P.; RUGH, J. D.; SAKAI, S. *et al.* Dietary intake in edentulous subjects with good and poor quality complete dentures. **J Prosthet Dent**, 87, n. 5, p. 490-498, May 2002.

SUZUKI, H.; KANAZAWA, M.; KOMAGAMINE, Y.; IWAKI, M. *et al.* Changes in the nutritional statuses of edentulous elderly patients after new denture fabrication with and without providing simple dietary advice. **J Prosthodont Res**, 63, n. 3, p. 288-292, Jul 2019.

SUZUKI, H.; KANAZAWA, M.; KOMAGAMINE, Y.; IWAKI, M. *et al.* The effect of new complete denture fabrication and simplified dietary advice on nutrient intake and masticatory function of edentulous elderly: A randomized-controlled trial. **Clin Nutr**, 37, n. 5, p. 1441-1447, Oct 2018.

TYROVOLAS, S.; KOYANAGI, A.; PANAGIOTAKOS, D. B.; HARO, J. M. *et al.* Population prevalence of edentulism and its association with depression and self-rated health. **Sci Rep**, 6, p. 37083, Nov 17 2016.

VAN KAMPEN, F. M.; VAN DER BILT, A.; CUNE, M. S.; FONTIJN-TEKAMP, F. A. *et al.* Masticatory function with implant-supported overdentures. **J Dent Res**, 83, n. 9, p. 708-711, Sep 2004.

VERLAAN, S.; LIGTHART-MELIS, G. C.; WIJERS, S. L. J.; CEDERHOLM, T. *et al.* High Prevalence of Physical Frailty Among Community-Dwelling Malnourished Older Adults-A Systematic Review and Meta-Analysis. **J Am Med Dir Assoc**, 18, n. 5, p. 374-382, May 1 2017.

YAMAZAKI, T.; MARTINIUK, A. L.; IRIE, K.; SOKEJIMA, S. *et al.* Does a mandibular overdenture improve nutrient intake and markers of nutritional status better than conventional complete denture? A systematic review and meta-analysis. **BMJ Open**, 6, n. 8, p. e011799, Aug 3 2016.