Oral Health-Related Outcomes in Edentulous Patients Treated With Mandibular Implant-Retained Dentures Versus Complete Dentures: Systematic Review With Meta-Analyses

Philip Kroll, DDS, MS[1]
Lisa Hou, DDS, MS[1,2]
Hani Radaideh, DDS, MS[1]
Nazanin Sharifi, DDS, MS[1]
Phuu P. Han, DDS, PhD[2]
Roseann Mulligan, DDS, MS[2]
Reyes Enciso, PhD[2]*

The objective of this systematic review was to determine the effect on oral health-related outcomes from mandibular implant-retained dentures opposing maxillary complete dentures in edentulous middle-age and older adults, compared with complete removable dentures in both arches. Randomized controlled trials included participants with an average age of 65 years or older. The Cochrane Library, MEDLINE, and Web of Science were searched. A total of 228 abstracts were reviewed for inclusion criteria, with 14 trials included and analyzed for risk of bias. Eleven of these studies were assessed as being at an unclear risk of bias, and 3 were at high risk. Mandibular implant-retained overdenture therapy showed statistically significant improvements in the patients' general satisfaction ($P = .003$), oral health-related quality of life ($P < .001$), and chewing ability ($P < .001$), over the patients with complete dentures. There were no significant differences in the percentage of patients who were satisfied with their overdentures vs complete dentures for comfort, retention, esthetics, or chewing ability; however, only 2 studies reported these outcomes. In terms of nutritional status 1 year after treatment, vitamin B_{12} blood levels increased significantly in the implant-retained group ($P = .003$), but not the other nutritional values. Implant-retained mandibular overdentures are an option for middle-aged and elderly edentulous patients as they significantly improve some of the outcomes; however, the quality of the evidence was moderate/low, due to the small number of studies included and the risk of bias. Future research should include objective outcomes such as masticatory performance, chewing efficacy, and muscular coordination.

Key Words: implant-retained overdentures, complete dentures, oral health-related quality of life, systematic review, meta-analyses

INTRODUCTION

The geriatric population in the United States is one of the fastest growing demographic groups and will almost double by 2050 with an estimated 83.7 million people aged 65 and over compared to 43.1 million in 2012.[1] Changes in the periodontium and teeth associated solely with aging are not sufficient to cause tooth loss,[2] whereas the increased incidence of oral diseases including caries, periodontitis, salivary hypofunction resulting from polypharmacy, physical disability, and less accessibility to dental care are all contributing factors for tooth loss in the geriatric population.[3–5] Edentulism can result in negative impacts on diet and food selection, functional and sensory changes of the oral mucosa, general and systemic health changes, and declines in general and oral health-related quality of life (OHRQoL) of older adults.[3,6] Patients who are edentulous or partially dentate often report difficulties in daily functioning activities related to chewing and speaking, and, in addition, social embarrassment and esthetic concerns.[7]

Until the 1980s, conventional complete dentures (CD) were the traditional method for the treatment of edentulism and a decrease in chewing efficiency of individuals wearing CDs when compared to natural teeth has been described as one of the negative effects.[8] Dental implants had been used before this time, but a survival rate of only 5 years was considered

[1] Herman Ostrow School of Dentistry, University of Southern California, Los Angeles, Calif.
[2] Division of Dental Public Health and Pediatric Dentistry, Herman Ostrow School of Dentistry, University of Southern California, Los Angeles, Calif.
* *Corresponding author,* e-mail: renciso@usc.edu
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successful (1978 Harvard Consensus Conference).[9] In the 1980s, information from Branemark's well-known research on oral implants, with its demonstrated greater longevity as a result of osseointegration, became well known. [10]

The advent of reliable dental implants created multiple options to treat edentulism beyond the traditional CD. Two popular therapeutic options can be described as: a complex, higher cost, fixed implant prosthesis secured to 4–6 implants per arch; and a less complex, lower cost prosthesis with 2 mandibular implants supporting a removable denture and with variations of attachments including ball-type and O-ring, clip, locator, and extracoronal-resilient, all opposing a complete maxillary denture.[11]

Implant-retained dentures (IOD) are purported to decrease the negative outcomes the elderly patient has often experienced with CDs: poor retention, poor stability, inability to chew, and inability to speak.[12] Implant-retained dentures have the potential for increased retention as well as patient comfort when compared to CDs, offering better comfort, stability, and chewing function, and thereby improving the OHRQoL of geriatric patients.[13]

The objective of this systematic review was to determine the effect on OHRQoL, patients' satisfaction, nutritional status, and improved function of mandibular implant-retained dentures when paired with a maxillary complete denture in edentulous middle-age and older adults as compared with complete removable dentures in both arches.

Materials and Methods

Studies reviewed were limited to randomized controlled trials (RCTs) that focused on the efficacy of mandibular implant-retained dentures in edentulous adults compared with conventional complete dentures. As some studies did not report the age range of the participants, and it was difficult to ascertain if all the patients were older than 65 years old, our systematic review was limited to studies where the average age of the participants was 65 years or older. Editorials, opinion letters, commentaries, reviews, systematic reviews, case studies, animal studies, cost-effectiveness studies, pharmacokinetic studies, and guidelines were omitted. RCTs reporting an average age of participants below 65 were also excluded along with articles not available in English. The outcomes under investigation were indicators of OHRQoL for edentulous patients, satisfaction with their dentures, nutritional status, and chewing efficiency.

Three electronic databases were searched for eligible RCTs. Details on the search strategies for the different electronic databases used are as follows:

- MEDLINE via PubMed (searched on March 28, 2016 and updated on April 13, 2017) was searched and further limited to human clinical trials (excluding animal studies) and to publications in the English language with the following search strategy:
  ("Dental Prosthesis, Implant-Supported"[Mesh] OR implant-retained dentures* OR implant supported dentures* OR implant dentures) AND (overdenture* OR conventional denture* OR complete denture* or removable partial denture* OR denture*) AND (edentulous OR edentulism) AND (health outcome* OR quality of life OR oral health OR masticatory efficiency OR maximum bite force) AND Humans[Mesh] AND English[lang]
- The Web of Science and The Cochrane Library (both searched on March 28, 2016 and updated on April 13, 2017) with the following search strategy:
  (implant-retained dentures* OR implant supported dentures* OR implant dentures) AND (overdenture* OR conventional denture* OR complete denture* or removable partial denture* OR denture*) AND (edentulous OR edentulism) AND (health outcome* OR quality of life OR oral health OR masticatory efficiency OR maximum bite force) AND random*

Data collection and analysis

Selection of Studies

Two review authors (L.H., P.K.) screened the title and the abstracts of the articles resulting from the search strategy. Duplications from the search were excluded and each title and abstract was assessed with exclusion and inclusion criteria. If a clear agreement could not be reached, the full article was reviewed by both reviewers. If there was a disagreement after reviewing the full article among the 2 reviewers, final inclusion was decided by a third author (R.E.). The entire text of the articles that matched the inclusion criteria was retrieved and reviewed by 2 additional review authors (H.R., N.S.) for inclusion. Authors (L.H., P.K., H.R., and N.S.) scanned the bibliography sections of the reviews, systematic reviews, and clinical guidelines from the original search as well as all eligible RCTs for any additional relevant references. Any new relevant study not in the initial search results was submitted to the inclusion criteria, reviewed by at least 2 authors out of 4 (L.H., P.K., H.R., and N.S.) and if there was disagreement, the full text was retrieved with a fifth author (R.E.) making the final decision.

Data Extraction and Management

Four review authors (L.H., P.K., H.R., and N.S.) independently extracted data from the full-text articles eligible for inclusion. Each reviewer extracted data from half of the studies and the data extracted was subsequently reviewed by a minimum of 2 other authors. The data extracted included demographics of the participants, control group, intervention group, method of intervention, and the outcome of the results. Any disagreement with the data and information extraction was resolved by a fifth review author (R.E.).

Assessment of Risk of Bias in Included Studies

The assessment of risk of bias for each included RCT was undertaken independently by 2 out of 4 reviewers (L.H., P.K., H.R., and N.S.) and reviewed by the other two, as part of the data extraction process, and in accordance with the approach described in the Cochrane Handbook.[14]

Statistical Analyses

Only studies comparing implant-retained overdentures to complete dentures reporting the same outcome measures

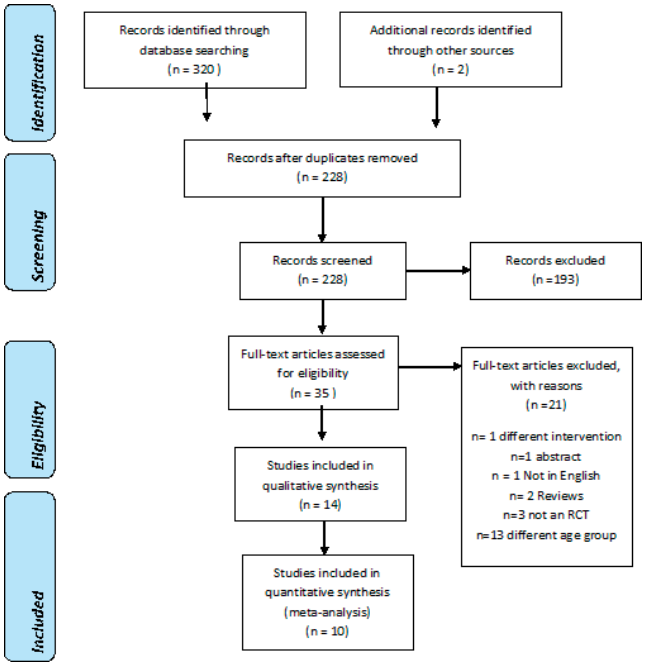


Figure 1. PRISMA flow diagram.

were included in the meta-analyses. Treatment effects were calculated to compare the results across studies. When authors reported medians and ranges, the results were converted to means and SD with the following formulas: mean = (min range + 2 × median + max range) / 4; SD = interquartile range (IQR) / 4; IQR = Max range − min range. When authors reported the SEM, results were converted to SD: SD = SEM × sqrt(N), with N as the sample size in that intervention group. Blood levels reported in μg/mL were converted to pmol/L. For dichotomous outcomes (satisfied or dissatisfied), treatment effects were expressed as risk ratios with 95% confidence interval (CI). For continuous outcomes reported with different scales such as general satisfaction (reported as a 0–100 or 0–1000 visual analog scale [VAS]), vitamin B12 (reported as μg/mL or pmol/L) and chewing efficiency, treatment effects were expressed as standardized difference in means (SDM) with 95% CI. SDM standardizes the measurements on a uniform scale. For continuous outcomes reported using the same scale such as OHIP-EDENT, albumin (g/L), C-reactive protein (CRP; mg/L), or the ability to chew (0–100 VAS), treatment effects were expressed as difference in means (DM) with 95% CI. Statistical heterogeneity was tested with Cochran's Q-test[15] and the I^2 statistic.[16] Estimates of effect were combined with a random effects model if there was heterogeneity (Q-test P value $< .10$), or with the fixed-effect model otherwise. All statistical analyses were performed by one author (RE) using Comprehensive Meta-Analysis version 3 software (Biostat, Englewood, NJ). An independent statistician reviewed and approved the statistical analyses.

Quality of the Evidence

Quality of evidence assessment and summary of the findings were conducted using the software GRADE profiler (GRADEpro), following the Cochrane Collaboration and GRADE Working Group.[14]

Results

Results of the search

The initial search strategy consisting of database searches yielded 320 articles and 2 additional records identified through other sources (scanning of the reference section of included studies). Duplicate articles were removed. Two review authors (LH, PK) independently assessed the abstracts of 228 unduplicated articles. Based on the abstracts and titles, the initial results were reduced to 35 relevant articles. Reasons for exclusions included the following: reviews or systematic reviews (n = 43); different outcome (n = 9); different age (n = 1 not adults); protocol of study (n = 4); different comparison group, that is, patients in the control group did not receive a complete denture (n = 3); duplicate reference (n = 3); editorial opinion (n = 2); pilot trial (n = 4); not an RCT (n = 52); different condition, that is, not edentulous patients (n = 18); and different intervention, that is, not an implant-retained mandibular denture (n = 54).

All 35 articles identified were searched for full-text and analyzed for inclusion independently by 2 review authors out of 4 (L.H., P.K., H.R., and N.S.). Fourteen articles were relevant for inclusion after full-text review. Reasons for exclusion were the following: average age of the participants below 65 years old (n = 13); different intervention (n = 1); not in English language (n = 1); literature review (n = 2); conference abstract (n = 1); and not a RCT (n = 3). Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart shows a summary of our search and exclusion results (Figure 1).

Included studies

Review authors searched 3 different databases (MEDLINE through PubMed, The Cochrane Library, and Web of Science) up until April 2017. Review authors also reviewed all the bibliographic references within the included studies, literature reviews, and systematic reviews generated from the search to ensure that there were no missed references.

Fourteen RCTs comparing mandibular implant-retained overdentures to conventional complete dentures of the mandibular arch in edentulous adults were eligible for qualitative analysis (Table 1).[17–30] All studies included both genders with approximately the same distributions. The average age of the subjects in each study was over 65 years old (by design) and included patients as old as 96 years in one of the studies.[29] It should be noted that in 1 study, one of the exclusion criteria stated that patients who were older than 80 years of age were excluded,[17] and another study excluded any patients over 74 years old.[19] Although the studies required the patients to be completely edentulous prior to starting the trials, some required subjects to be edentulous for 5 years or more.[17,19,20,24–26,28,30] A few studies required the patients to replace their inadequate dentures to be included.[19,20,22,23,26,28–30] Because the patients were required to fill out questionnaires regarding quality of life and function post-

Table 1

Summary of risk of bias for eligible RCTs

Reference	Inclusion Criteria	Measures of OHRQoL and Satisfaction
Allen et al[17]	(a) that the individuals were medically fit enough to undergo minor oral surgery (b) that dental implants could be placed into the lower jaw without the need for bone augmentation procedures (c) that patients had been edentulous for more than 5 y (d) that patients were no more than 80 years of age	OHIP-49 General satisfaction (Likert scale 1–5)[34]
Awad, Lund et al[19]	(a) wearing present dentures on regular basis (b) edentulous for minimum of 5 y (c) capable of reading and writing in French (questionnaire language) (d) able to fill out sample questions (e) able to allow placement of 2 implants—adequate bone support with no TMD or clenching	OHIP-49 OHIP-EDENT General satisfaction (VAS 0–100)
Awad Morais et al[20]	(a) male and females (b) 65+ years of age (c) edentate for minimum of 5 y (d) wish to replace their existing CDs (e) adequate understanding of written and spoken English or French (f) willing and able to understand the protocol and give informed consent	None
Emami et al[21]	(a) edentulous patients who would like to have dentures	OHIP-20[26]
Farias Nieto et al[22]	(a) fully edentulous (b) needs new dentures (c) able to read and respond to written questionnaire in Portuguese	Overall satisfaction (0–100 scale)[44]
Gjengedal et al[23]	(a) history of wearing complete denture in both arches (b) complaints of dissatisfaction with mandibular prosthesis (c) ≤76 years of age (d) dentures of acceptable technical quality (e) no defect of teeth, denture base, fit, occlusion or articular and with acceptable vertical dimension (f) acceptable general health	None
Gonçalves Assunção et al[18]	Edentulous patients	Variation of OHIP
Hamdan et al[24]	(a) ≥65 y male or female (b) edentulous for minimum of 5 y (c) adequate understanding of written and spoken English and French	None
Heydecke, Klemetti et al[25]	(a) history of edentulous for at least 5 y (clinical examination completed by prosthodontist using 8 category scales proposed by McGarry et al[46] (including height/resorption and profile of the mandibular ridge, quality of the mandibular mucosa and occlusion)	General satisfaction (VAS 0–100)
Heydecke, Locker et al[26]	(a) males and females (b) 65–77 years of age (c) edentulous for 5 y (d) patient wants replacement of existing complete dentures (e) ability to understand and respond to the scales used in the study	OHIP-20
Jofre et al[27]	(a) male and female between 45–90 years of age (b) instability of conventional mandibular dentures (c) no temporomandibular disorders	OHIP-EDENT
Morais et al[28]	(a) male and female between 65–75 years of age (b) complete edentulism for more than 5 y (c) patient wants replacement of existing complete dentures (d) ability to understand and respond to scales used	Patient's satisfaction (Likert scale 1–5)
Müller et al[29]	(a) 75 years of age and older (b) living institutionalized or receiving help for activities of daily living as assessed with Instrumental Activities of Daily Living Scale (Lawton and Brody[47])—ability to dress and feed oneself, continence, mobility, toilette (c) edentulous and wears CD (d) lower denture has to cause discomfort to the degree that patients were seeking treatment	OHIP-EDENT Denture satisfaction (VAS 0–10)
Pan et al[30]	(a) male and females 65 years of age or older (b) edentulous for minimum of 5 y (c) wishing to replace existing dentures (d) adequate understanding of written and spoken English or French (e) able to understand and respond to questionnaires used in the study	McGill Denture Satisfaction (0–100 scale)[33]

*IOD indicates implant-retained overdentures; CD, complete dentures; OHRQoL, oral health-related quality of life; OHIP, oral health impact profile; OHIP-EDENT, oral health impact profile edentulous patients; TMD, temporomandibular disorder; VAS, visual analog scale.

TABLE 2

Characteristics of the implants and attachments used in the included studies*

Study	# Of Implants Used/Patient	Manufacturer	Attachment Type Used
Allen et al[17]	2	Branamark	Ball and O-ring
Awad et al[19]	2	Straumann	"Clip type ball" (Ball and O-ring)
Awad Morais et al[20]	2	Straumann	Ball and O-ring
Emami et al[21]	2	Straumann	Ball and O-ring
Farias Neto et al[22]	2	Conexao Sistemas de Protese Ltda	Splinted bar with bar-clip/2 impl
Gjengedal et al[23]	2	Astra-Tech	Locator (Zest Anchors)
Gonçalves Assunção et al[18]	2–5	Branamark	Ball and O-ring/patients w/2 impl Bar-clip/patients w/3 impl Bar-clip+distal ball w/4 or 5 impl
Hamdan et al[24]	2	Straumann	Ball and O-ring
Heydecke et al[25]	2	ITI	Ball and O-ring
Heydecke et al[26]	2	ITI	Ball and O-ring
Jofre et al[27]	2	Sendax (small diameter 1.8mm)	Splinted-cemented bar and immediately loaded. Attachment not described.
Morais et al[28]	2	Straumann	Ball and O-ring
Müller et al[29]	2	Straumann	Locator (Zest Anchors)
Pan et al[30]	2	"Standard Implants," Manufacturer not named	Ball and O-ring

*impl indicates implants.

treatment, most studies required the patients to be able to speak and understand the language in which the questionnaire was administered.[19,20,22–24,26,28,30]

It was noted that patients who had insufficient bone for placement of 2 implants,* as well as chronic and acute symptoms of temporomandibular disorders[19,20,22,24,26,30] were excluded in some studies, as were patients who had any systemic conditions or neurologic diseases that contraindicated implant surgeries and any oral manifestations of systemic conditions.[20,22,24,26–30]

Patients with immunosuppression,[29] any neoplasia diagnosed in <5 years,[20,24,30] or who had history of radiation therapy[27,30] and patients who were taking bisphosphonates,[29] antineoplastic medications, phenytoin, or corticosteroids were excluded from some studies as well.[20,24,26–30] Patients with a body mass index (BMI) <20 kg/m^2[20,24,30] or obesity,[26,28] or patients with any current use of dietary supplements[20,24] were also excluded from the studies. Smokers were excluded from 3 studies.[23,26,28] Patients with psychological or psychiatric disorders,[22,26,28,30] or patients with any memory deficits and who score lower than 24 on the Mini-Mental State Examination were excluded from a few studies.[24,29,30]

For the implant group, the number of patients completing the study ranged from 17[17] to 113,[30] while for the complete dentures group, sample size ranged from 15[22] to 128.[24] Seven studies had patients who dropped out after the treatment.[17,20,23,24,28–30] Most patients received at least 2 implants on the anterior of the mandibular arch, except for 1 study where a maximum of 5 implants[18] were placed after healing time, when an implant-retained overdenture was fabricated and delivered at the same time as a maxillary conventional complete denture. In 1 study the implants were splinted and loaded immediately at the time of surgery.[27] For patients in the comparison CD group, conventional maxillary and mandibular dentures were fabricated, with prostheses for both arches delivered at the same time. Additionally, different types of retention systems were used including: ball attachments and O-rings, bar-clip attachments and distal ball type attachments (Table 2). In 2 studies, the implants were splinted together,[22,27] whereas 1 study did not identify implant or attachment manufacturer.[30] In all but 1 study, the patients lived independently. The exception examined subjects who were residents of institutions or receiving help for activities of daily living as assessed with Instrumental Activities of Daily Living Scales.[29]

Outcomes

The outcomes measured were indicators of OHRQoL, satisfaction with the dentures, nutritional status and chewing efficiency. In particular, OHRQoL was reported using the Oral Health Impact Profile (OHIP) in its original version with 49 questions (OHIP-49),[31] a short version with 20 questions (OHIP-20),[26] or the impact of oral health on the quality of life of edentulous patients with complete dentures (19-item OHIP-EDENT).[32] Responses to OHIP-20, OHIP-49, and OHIP-EDENT questions about functional limitation, physical pain, psychologic discomfort, physical disability, psychologic disability, social disability, and handicap, were all made on a 5-point Likert scale (0 = never, 1 = hardly ever, 2 = occasionally, 3 = fairly often, 4 = very often),[31] with lower scores indicating better OHRQoL.

The patients' overall satisfaction with their prostheses were reported using various questionnaires including the VAS, which was marked on a 0–100 mm line,[19,22] or a 0–1000 line,[29] the McGill Denture Satisfaction[33] (VAS 0–100 scale), and a 1–5 Likert scale.[34] Authors also reported satisfaction with esthetics, comfort, stability, and ability to chew and speak on a VAS 0–100 mm scale[19,30] or as "satisfied," "tolerate," "unsatisfied/dissatisfied."[18,22] Secondary outcomes included nutritional status in 3 studies[20,24,29] based on blood panel measurements for vitamins, albumin, folic acid, serum albumin, and CRP. Chewing efficiency as an objective outcome was reported in 2

* *References 17,19,20,23,24,26,28,30.*

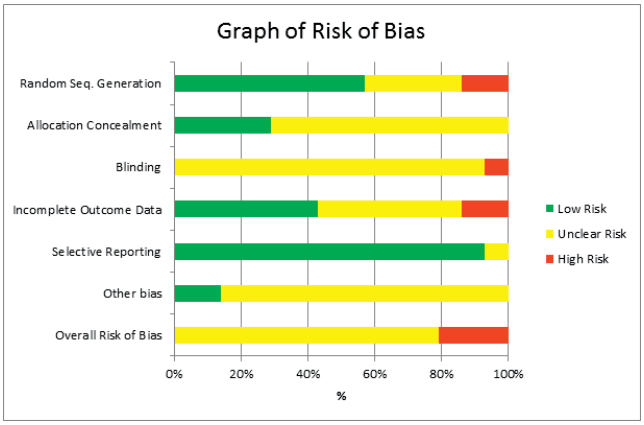


Figure 2. Summary of risk of bias of eligible randomized controlled trials.

studies, using beads and an ultraviolet-visible spectrophotometer in 1 study[22] or a 2-color chewing gum masticated for 20 cycles measured by photoelectronic analysis in a second study.[29]

Risk of bias in included studies

A summary of risk of bias graph (Figure 2) shows 3 studies[17,23,29] were deemed at high risk of bias; all remaining 11 trials were judged as unclear.

Random Sequence Generation

The method of sequence generation was identified as low risk of bias in 8 studies[19–22,24,26,27,29] (internet-based program, block randomization, or computer-generated randomization). Four included studies[18,25,28,30] were identified as having unclear risk of bias because the authors reported that the patients were randomized, but did not provide any details on the method of randomization. One study[17] was identified at high risk of bias because the patients in the implant (intervention) group were offered conventional dentures if they refused implants (crossover), thus breaking the randomization. The other high-risk study[23] provided no clear randomization strategy. The patients were selected from 2 cohorts of previous studies: the first cohort study recruited patients who were currently dissatisfied with their mandibular conventional complete dentures whereas the second cohort were participants who responded to a newspaper advertisement.[23]

Allocation Concealment

The allocation concealment was well reported by 4 studies[23,24,27,29] and assessed at low risk of bias because authors used sealed envelopes to hide the randomized code, or various block sizes were used to preserve allocation concealment and reduce potential selection bias.[24] In 1 study,[29] the randomization sequence was established before recruitment of the study commenced and concealed in nontransparent consecutively numbered envelopes. After enrollment of a participant, the next randomization envelope was opened, according to the established sequence. In a second study,[27] allocation was completed by an outside third party, and participants and personnel were not aware of the assignments. In another study,[23] the patients who participated in the first recruitment blindly drew a ticket from an original stack of 16 to determine treatment allocation, with 8 tickets for each of the 2 treatment modalities. The allocation concealment was not stated in 10 studies, which were scored as unclear risk.

Blinding

Blinding is difficult or fairly impossible in this type of intervention study due to the presence of implant placement in the treatment group vs no implants in the control group. The patients all knew the nature of their interventions after treatment since it would have been nearly impossible to conceal from both the patient and assessor. As a result, it was not unexpected that all 14 trials failed to report how blinding was achieved for all parties involved in the studies (participants, personnel delivering the intervention, outcome assessors, and data analyst). Therefore the risk of bias for 13 studies was assessed as unclear risk (Figure 2), and 1 study was assessed at high risk[17] as patients were given the choice of the intervention. This was the study[17] in which the implant group patients were initially offered an implant-retained prosthesis in the lower jaw and a conventional complete denture in the upper jaw. If the patients refused implants, then conventional complete dentures were offered for both arches: clearly there is no doubt that blinding was not part of this study's protocol. Conversely in this study those allocated to the conventional denture group were not allowed to join the implant-retained group.

Incomplete Outcome Data

Six trials had no dropouts or incomplete outcome data and were assessed as being at low risk of bias for this domain.[18,22,23,26–28] Another 6 studies were considered to have an unclear risk of bias.[19–21,24,25,30] In 5 trials, dropouts were accounted for and groups had balanced number of dropouts, but the authors did not provide an intent-to-treat analysis.[19–21,24,30] In 1 study,[25] authors were unable to properly account for all participants at the conclusion of the trial.

Two studies[17,29] were at high risk of bias for incomplete outcome data. In one of these,[17] there was no intent-to-treat analysis, an unbalanced number of dropouts between the IOD and the CD groups, and the reasons to refuse treatment were related to the intervention, as 17 out of the 62 patients in the implant group refused treatment and were offered complete dentures.[17] In the second study at high risk,[29] although it appears that all outcome data is addressed, there were large numbers of dropouts in both the intervention and control groups (39% and 59%, respectively).

Selective Reporting

Thirteen of the included studies were assessed at low risk for selective reporting[17–22,24–30]; however, the reporting for 1 study[23] was unclear, as there were no reports of nutritional status outcomes for each group of patients receiving IOD or CD, but rather results were provided for all the participants in the aggregate.

Other Potential Sources of Bias

Two studies[18,27] did not have any other potential sources of bias and were therefore considered to be at low risk of bias; 12 studies[17,19–26,28–30] were categorized as unclear risk of bias, because the manufacturers of dental implants used in the trials provided financial support and funding.

Effects of interventions (meta-analyses)

Only RCTs comparing IODs to CD reporting similar outcome measures were included in the meta-analyses. Of the 14 studies included in this review comparing IOD versus CD for the middle-aged and older edentulous patients, only10 could be included in the meta-analyses due to missing information (ie, missing SD of the data or only 1 group's data reported and not the other).

Four of the studies included data on OHIP-EDENT,[19,26,27,29] (Figure 3); and another 4 studies[17,19,29,30] used a 0–100 mm or 0–1000 scale to compare general satisfaction (Figure 4). Two studies compared the percentage of satisfied patients[18,22] (Figure 5a), whereas another 2 studies included a measurement of chewing ability based on a VAS score[19,30] (Figure 5b). Five studies assessed nutritional status using blood values with 3 of these studies comparing vitamin B12 and folate[20,24,29] before and after the intervention while 2 studies compared albumin and CRP.[20,29]

OHIP-EDENT

Four studies[19,26,27,29] reported means and SD of OHIP-EDENT total score at baseline and post-treatment. There was no statistical heterogeneity among the four studies (Q *P*-value = .273; $I^2 = 23\%$). Using the fixed-effect model and the random effects model, the results were very similar; implant-retained overdentures provided significantly improved OHIP-EDENT by 12.2 VAS units compared to complete dentures in edentulous patients (95% CI = −17.418 to −6.950; $P < .001$) (Figure 3).

OHIP

Insufficient data were reported by the authors to perform a meta-analysis. Only 1 study[19] reported baseline and post-treatment OHIP-49 for both groups. One study showed the data in the form of a graph with a median value and range[17]; a second study provided a variation of an OHIP questionnaire for all patients with no OHIP data reported per group[18]; and finally 1 study provided OHIP-20 post-treatment data but no baseline data per group.[21] In 1 study,[18] authors were unclear on whether they were using OHIP-49 or OHIP-20 scales.

General Satisfaction (VAS)

Three studies[19,29,30] reported means and SD of VAS general satisfaction with 2 different scales 0–100 and 0–1000, or the post-treatment mean and 95% CI, and could be included in the meta-analysis. One study[17] reporting general satisfaction using a 1–5 Likert scale with 1 = "extremely satisfied" and 5 = "extremely dissatisfied" was not included. There was statistical heterogeneity among the 3 studies[19,29,30] (Q *P*-value = .035; $I^2 = 70\%$). Using the random effects model, implant-retained prosthesis provided significantly higher general satisfaction than complete dentures in middle-aged and older adults (SDM = 0.770; 95% CI = 0.258 to 1.282; $P = .003$) (Figure 4).

Percent of Satisfied Patients

Two studies[18,22] reported on the percentage of patients satisfied with comfort, stability/retention, esthetics, and chewing. No statistical heterogeneity among the 2 studies was found (Q *P*-value $> .05$) and fixed-effect models was used. When asked to rate their satisfaction with their implant-retained dentures compared to those patients receiving conventional dentures, there were no statistically significant differences in terms of comfort (risk ratio [RR] = 1.103; 95% CI = 0.943 to 1.290; $P = .222$), stability/retention (RR = 1.153; 95% CI = 0.959 to 1.358; $P = .130$), nor esthetics (RR = 1.088; 95% CI = 0.953 to 1.242; $P = .212$). A trend toward significance was found for the percent of patients satisfied with their chewing ability favoring the implant group (RR = 1.214; 95% CI = 0.995 to 1.482; $P = .056$) (Figure 5a).

Chewing Ability

Two studies[19,30] reported the chewing ability of the patients in a VAS scale 0–100. Patients in the implant group reported a significantly higher ability to chew of 18.179 units on a 0–100 scale (95% CI = 11.970 to 24.388; $P < .001$) (Figure 5b).

Chewing Efficiency

In terms of masticatory efficiency as an objective outcome, it was reported in 2 studies with different methods: using beads and an ultraviolet-visible spectrophotometer in 1 study[22] and a 2-color chewing gum masticated for 20 seconds then measured by photo-electronic analysis in a second study.[29] As 1 study[22] did not report the baseline data, we compared the 3-month post-treatment results. There were no significant differences in chewing efficiency at 3 months between the implant and the complete denture groups ($P = .942$).

Blood Panel

Nutritional status of the edentulous patients 1 year after treatment was assessed based on a blood panel in 3 studies[20,24,29] reporting vitamin B_{12} and folate levels of the patients at baseline and after 12 months of treatment. A significant increase in vitamin B_{12} values was found favorable to the implant group (SDM = 0.280; 95% CI = 0.095 to 0.465; $P = .003$). No statistical difference was found in folate levels ($P = .872$). Two studies[20,29] reported albumin and CRP of the patients at baseline and after 12 months of treatment with no statistical difference found in albumin levels ($P = .170$) or CRP levels ($P = .605$).

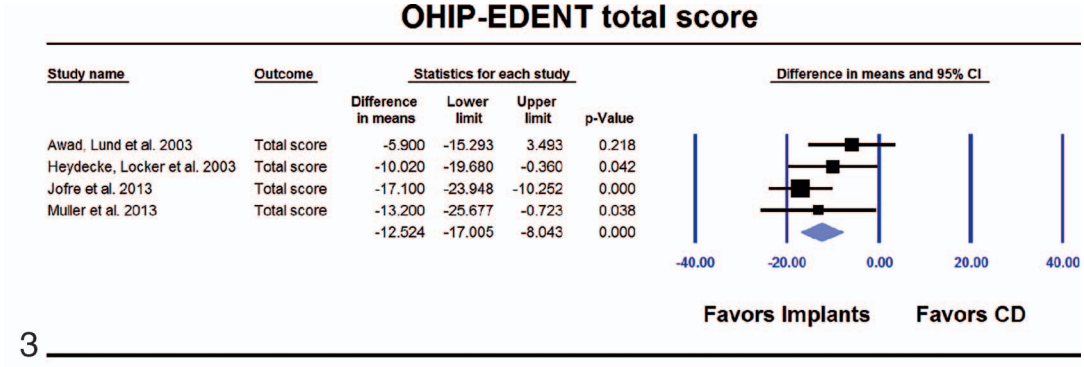
Quality of the evidence (GRADE)

Only RCTs reporting similar outcomes were pooled into a meta-analysis. Due to unclear or high risk of bias, the small total sample size of participants in each meta-analysis, plus the small number of studies pooled (between 2 and 4), the quality of the evidence was low to moderate (Table 3).

Discussion

Agreements and disagreements with

In this systematic review with meta-analyses, studies were included only if the average age was above 65 years old.



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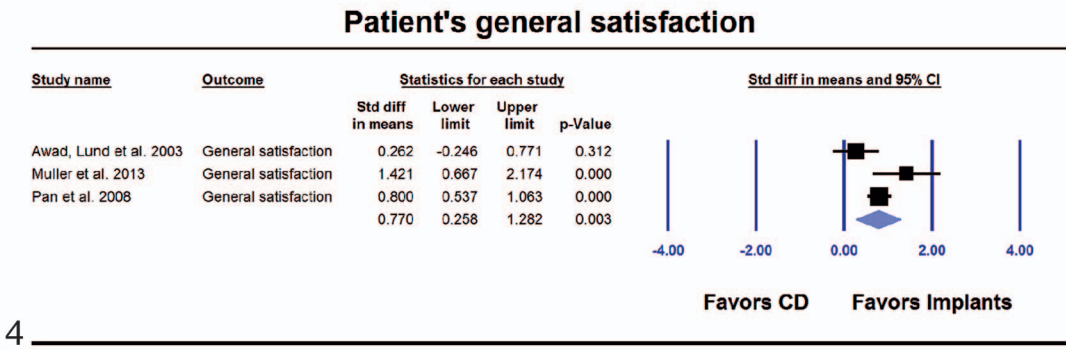

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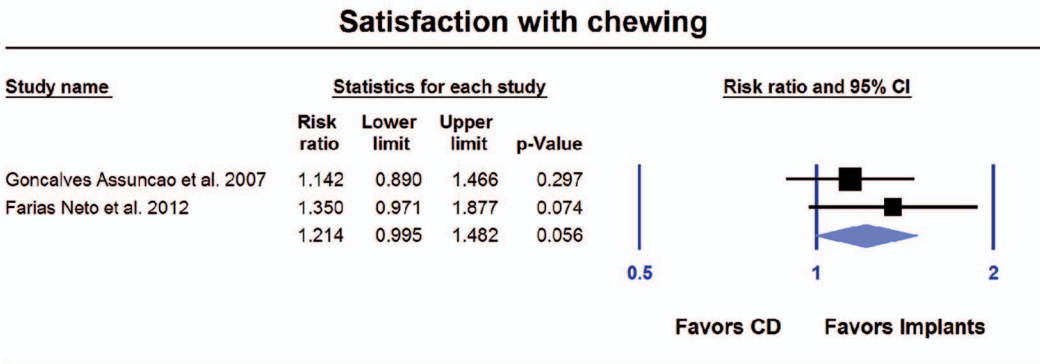
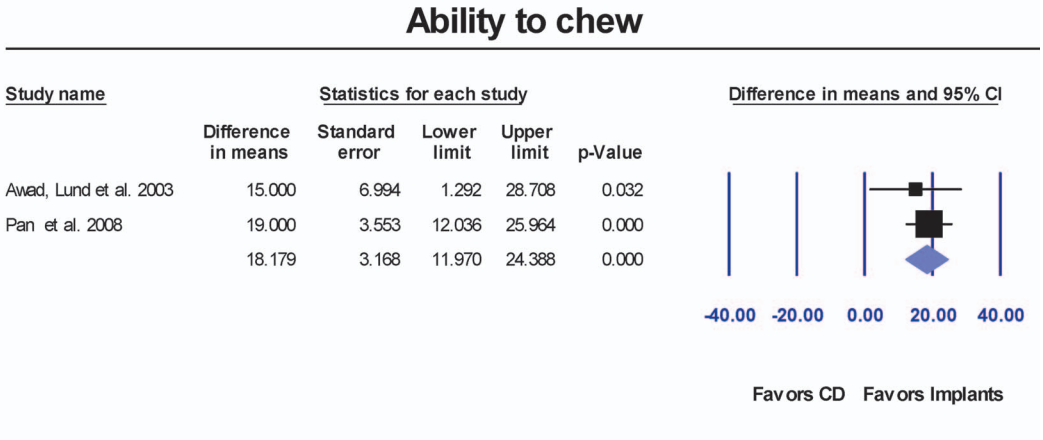


5a



5b

Figure 3–5. Figure 3. Oral health impact profile edentulous patients (OHIP-EDENT) total score. Significant decrease in OHIP for edentulous patients favorable to the implant group compared to complete dentures (CD) group ($P < .001$). **Figure 4.** Patient's general satisfaction (visual analog scale) with the overdentures and complete dentures. Significant increase in patient's satisfaction favorable to the implant group compared to CD group ($P = .003$). **Figure 5.** Meta-analysis of RCT studies: (a) percent of patients satisfied with chewing: a nonsignificantly higher patient's satisfaction with chewing was found in the implant group ($P = .056$); (b) ability to chew: a statistically significantly higher ability to chew based on patient's questionnaire in the implant group ($P < .001$).

TABLE 3

Summary of quality of evidence findings (GRADE).[14]* Implant-retained dentures compared to complete dentures for improving oral health-related quality of life in fully edentulous middle-aged and older adults.

Outcomes	No. of Participants (Studies) Follow-up	Quality of the Evidence (GRADE)	Relative Effect (95% CI)	Anticipated Absolute Effects	
				Risk With Complete Dentures	Risk Difference With Implant-Retained Dentures (95% CI)
Impact of oral health on the quality of life of edentulous patients OHIP-EDENT	184 (4 studies) 2–12 mo	⊕⊕⊕⊖ MODERATE† due to risk of bias			The mean impact of oral health on the quality of life of edentulous patients in the implant-retained groups was 12.184 VAS units lower (17.418 to 6.950 lower)
Patient's general satisfaction VAS	334 (3 studies) 2–6 mo	⊕⊕⊕⊖ MODERATE† due to risk of bias			The mean patient's general satisfaction in the implant-retained groups was 0.770 standard deviations higher (0.258 to 1.282 higher)
Patient's satisfaction with their chewing ability	63 (2 studies) 2–3 mo	⊕⊕⊖⊖ LOW†‡ due to risk of bias, imprecision	RR 1.214 (0.995 to 1.482)	Study population 774 per 1000 Moderate risk -	166 more per 1000 (from 4 fewer to 373 more)
Chewing ability VAS 0–100	300 (2 studies) 2–6 mo	⊕⊕⊖⊖ LOW†‡ due to risk of bias, imprecision			The mean chewing ability in the implant-retained groups was 18.179 VAS units higher on a 0–100 scale (11.97 to 24.388 higher)
Chewing efficiency	63 (2 studies) 3 mo	⊕⊕⊖⊖ LOW†‡ due to risk of bias, imprecision			The mean chewing ability in the implant-retained groups was 0.050 standard deviations higher (1.294 lower to 1.394 higher)
Vitamin B12 blood panel	458 (3 studies) 12 mo	⊕⊕⊕⊖ MODERATE† due to risk of bias			The mean vitamin B12 in the implant-retained groups was 0.280 standard deviations higher (0.095 to 0.465 higher)
Folate blood panel	458 (3 studies) 12 mo	⊕⊕⊕⊖ MODERATE† due to risk of bias			The mean folate level in the implant-retained groups was 0.028 standard deviations lower (0.369 lower to 0.313 higher)
Albumin blood panel	241 (2 studies) 12 mo	⊕⊕⊖⊖ LOW†‡ due to risk of bias, imprecision			The mean albumin in the implant-retained groups was 0.500 g/L lower (1.214 lower to 0.214 g/L higher)
CRP blood panel	241 (2 studies) 12 mo	⊕⊕⊖⊖ LOW†‡ due to risk of bias, imprecision			The mean CRP in the implant-retained groups was 2.407 mg/L higher (6.717 lower to 11.531 mg/L higher)

*CI indicates confidence interval; RR, risk ratio; GRADE Working Group, grades of evidence; OHIP-EDENT, oral health impact profile edentulous patients; VAS, visual analog scale; high quality, further research is very unlikely to change our confidence in the estimate of effect; moderate quality, further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate; low quality, further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate; very low quality, we are very uncertain about the estimate.

†All studies assessed at unclear or high risk of bias.

‡Only two included studies, small sample size.

However, in this section we will discuss reviews that had no age limits due to the scarcity of reviews in older adults in this topic.

Patients' satisfaction and OHRQoL

Our results agree with prior reviews,[35–41] which stated superiority of the mandibular IOD therapy over the conventional CD regarding patient satisfaction. In a literature review in 2006,[41] edentulous patients benefited significantly from the use of dental implants to support mandibular prostheses, including an improvement in OHRQoL (measured with OHIP-49), satisfaction (VAS), esthetics, and speech function;[41] while in a departure from our findings, they reported removable implant overdentures as having had no impact on chewing ability over a mandibular CD, despite having acceptable retention with ball or bar attachment.[41] In a systematic review in 2015, the authors concluded in agreement with this review that adult mandibular edentulous patients experience higher satisfaction with an IOD when compared to CDs.[37] The evidence was insufficient for edentulous patients treated with an IOD in the maxilla.

In another recent systematic review published in 2016 that

discussed 4 studies measuring the OHRQoL scale with OHIP-49 and 1 study using the OHIP-20 scale, the authors found a statistically significant difference favoring the implant group for OHIP total score, functional limitation, psychological discomfort, physical disability, psychological disability, social disability, and handicap in edentulous adult patients.[42] These results are in line with our systematic review, with a favorable improvement in OHIP-EDENT in the implant group, though the inclusion criteria and meta-analyses performed in both systematic reviews are different.

Nutritional Status

In a systematic review[39] where the focus of the review was on nutritional effects of implant therapy in edentulous patients, the authors found conflicting results, as was true of our findings. In a more recent review by Yamazaki et al,[43] pooled analysis suggested no significant difference in change in BMI, albumin, or vitamin B_{12} between patients treated with an overdenture and CD 6 months after treatment.

In a recent systematic review published in 2015, Boven et al[36] focused on studies where maxillary and/or mandibular complete dentures were replaced with implants to support the dentures in adults. This is a slightly different question than we pursued in our review where we had a mix of patients, some having never had a CD and some who had had a CD before. The authors concluded that implant-retained dentures improved the patient's chewing efficiency, increased maximum bite force and clearly improved satisfaction; they did not find any effect on the nutritional state of the patients.[36]

In our opinion, the effects on nutritional state in edentulous subjects treated with implant-retained complete dentures are unclear. Although nutritional measurements in the form of blood tests could be useful in some situations, the variability between patient profiles, the reliability of the actual test itself, and the size of the cohort being studied are all problematic in using this outcome to assess the relative impact of various dental prostheses.

Applicability of Evidence

The results from this systematic review apply to older patients over the age of 65, with the oldest being 96. However, these results do not apply to individuals who have current oral manifestations of systemic conditions, chronic/acute temporomandibular joint disorder, or patients on certain medications (bisphosphonate, antineoplastic, phenytoin, and corticosteroids) as those patients were often excluded from the studies.

Implications for Research

Implant-retained mandibular overdentures can significantly improve patients' OHRQoL and satisfaction. However, the effect on nutritional status and chewing efficiency is still uncertain due to the small number of RCTs and the small sample size. It is important to note that while the evidence came from randomized controlled trials, patient questionnaires including the OHIP-EDENT and VAS scores present data that is by design subjective in nature. Although blood panels provide the researcher with objective outcomes of nutritional status, those outcomes may not be helpful due to a number of confounding factors. Future research should include not only subjective patient's satisfaction questionnaires (such as OHIP-DENT,[32] the McGill Denture Satisfaction Instrument[33] or overall satisfaction[44]), but rather objective outcomes, such as chewing efficiency (measured by photo-electronic analysis[29] or ultraviolet-visible spectrophotometer[22]), or masticatory performance (in terms of number of masticatory strokes, the swallowing threshold, and masticatory frequency), comminution tests, and muscular coordination measured by electromyography.[45]

There is a need for additional large sample RCTs with improved blinding techniques, for instance, having the personnel providing the intervention, as well as the outcome assessors and statisticians not being part of the study (ie, independent and separate from the researchers conducting the study and responsible for publication). Public or independent funding would be preferable to private funding to avoid bias. Standardized patient reported outcome measures and objective assessment tools must be developed. Further research is recommended to consider cost analyses on the impact of mandibular implant overdentures vs conventional dentures.

Conclusions

In summary, there is moderate/low evidence that implant overdentures can improve: the patients' OHRQoL measured with the instrument OHIP-EDENT, general satisfaction with their dentures, and their ability to chew (VAS). No significant difference was found between implant-retained dentures and complete dentures in other outcomes analyzed. This evidence has clinical value for dentists treating the expanding older adult population. Dentists should be aware that the implant overdenture protocol should be considered an important and valid clinical option for their older edentulous patients in terms of quality of life, satisfaction, and chewing ability, and should not be reserved only for younger populations.

Abbreviations

N: sample size
CD: complete dentures
CRP: C-reactive protein levels
IOD: implant-retained dentures
IQR: interquanrtile range
OHIP: oral health impact profile
OHIP-EDENT: oral health impact profile edentulous patients
OHRQoL: oral health-related quality of life
RCTs: randomized controlled trials
RR: risk ratio
SDM: standardized difference in means
VAS: visual analogue scale

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