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A comparative evaluation of masticatory efficiency and patient satisfaction between single implant-supported mandibular overdentures and conventional dentures in edentulous patients: A systematic review

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ABSTRACT

Aim This was to access the changes in masticatory efficiency and patient satisfaction of single implant supported mandibular overdentures (SIMO) vs conventional complete dentures (CCD).
Method We performed a literature search of published articles in MEDLINE database via PubMed, Google Scholar, Cochrane Central Register Of Controlled Trials (Central), from July 2020 till September 2020. We searched for studies in English without time restrictions, including articles since 1997 upto 2020. Inclusion criteria in our study were randomized controlled trial (RCT) evaluating masticatory efficiency or patient satisfaction with SIMO and CCD, prospective studies with before-after comparisons, prospective studies with at least 10 SIMO patients. Studies must include conventional denture wearers as an active comparator (control group), and single-arm prospective studies must assess patients treated with conventional dentures as the baseline treatment. Masticatory efficiency or patient satisfaction had to be assessed in the study. Exclusion criteria were studies in languages other than English, Reviews, case reports, abstracts, editorials, letters, animal experiments, historical reviews and *in vitro* studies.
Result We followed the PRISMA guidelines. A total of 14 studies over the past three decades met the inclusion criteria for full text reading and all 14 were included for further analysis. Statistical analyses were performed using Review Manager version 5.3 (The Nordic Cochrane Centre, Copenhagen, Denmark).
Conclusion Within the limitations of this study, it can be concluded that a considerable improvement was found with SIMO in masticatory efficiency and patient satisfaction, especially for maladaptive CCD wearers. It could be considered as a future paradigm for treatment of edentulous mandibles. Further studies designed with standardized measuring protocols, large sample size and long-term follow-ups are indicated to add evidence and support for the indication of SIMO.

KEYWORDS Mandibular overdenture, Conventional denture, Masticatory efficiency.

INTRODUCTION

Edentulism is a chronic condition and mostly affects the elderly population (1). Edentulism is defined as the loss of all permanent teeth and is the terminal outcome of a multifactorial process involving biologic processes (caries, periodontal disease, pulpal pathology, trauma, oral cancer) as well as non-biologic factors related to dental procedures (access to care, patient's preferences, treatment options etc.) (2). It is a debilitating and irreversible condition and is described as the "final marker of disease burden for oral health" (3). Complete denture rehabilitation remains one of the most popular and traditional prosthodontic treatment options for edentulous patients who have systemic, anatomic, and/or financial limitations (4).
A complete denture is a removable appliance used when all teeth within a jaw have been lost and need to be prosthetically replaced. Quality of a denture depends upon a number of factors such as retention, stability, vertical dimension, occlusion, esthetics, speech, difficulty in chewing, etc. (5). Denture retention and stability facilitate the restoration of oral functions such as mastication, speech, increase patient comfort and self-confidence (6). The masticatory function (MF) of edentulous patients is significantly compromised, compared with that of natural dentitions. To compensate for their impaired mastication, edentulous patients have to adjust their swallowing habits to ingest larger particles, or avoid tough food requiring mastication, thus leading to nutritional deficiency. Therefore, preserving or restoring proper mastication is of great importance in dental care (7).
It is well known that extraction of teeth leads to alveolar

bone resorption and this is more dramatic in the mandible than the maxilla. Tooth extraction in the mandible will result in continual reduction in alveolar bone volume. The continued resorption of the mandibular alveolar bone is associated with greater difficulty in mandibular denture construction, use, and satisfaction (8). Retention and stability problems of the mandibular prostheses often result in inability to chew food, decreased self-confidence and quality of life, as well as decreased social contact and satisfaction (9). A lack of satisfactory occlusion between the mandibular and maxillary dentures causes the mandibular denture to be a failure (10).. Factors that adversely affect successful use of a complete denture on the mandible include: (a) the mobility of the floor of the mouth, (b) thin mucosa lining the alveolar ridge, (c) reduced support area (d) the motion of the mandible and greater rate of alveolar bone resorption. These factors are the reasons why patients experience difficulty with using a complete denture on the mandibular arch compared to the maxillary arch (11). For these difficult clinical situations, especially for patients with edentulous mandible, implant- supported or implant-retained dentures are recommended to improve denture retention and stability, and increase overall oral comfort, function and psychosocial well-being.

A successful treatment option could be placing implants in the edentulous jaw and connecting it to the denture through an attachment similar to that of a tooth supported overdenture. The McGill consensus in 2002 and York consensus in 2009 proved the ability of implant supported overdenture to enhance masticatory efficiency. The reports of these consensus meetings have concluded that conventional dentures should be no longer used as a standard option for the treatment of edentulism. Instead, a two-implant supported mandibular overdenture should be the standard choice for treatment (12). The success of these treatment modalities, while excellent, is unfortunately outside the financial scope of many compromised edentulous patients. A cost comparison study between an unsplinted 2-implant retained mandibular overdenture and a conventional complete mandibular denture showed the direct cost of the overdenture to be 2.4 times the cost of the complete denture. It is, therefore, desirable for clinicians to be able to offer a significant functional improvement of the problematic mandibular complete denture in a cost effective manner (13). Single implants, which are less expensive than multiple implants, have become popular in recent years because of potential surgical advantages, along with the improvements in both clinical and patient oriented outcomes (14). The use of a single implant placed in the mandibular symphysis region to retain mandibular overdenture can be considered as an alternative modality and is proposed to be applicable on a global scale for a wider range of edentulous populations in different socio-economic groups. Cordioli et al. (1997) monitored 15 patients for 5 years, each with a mandibular overdenture attached with a ball abutment and rubber O- ring to 1 mid-line implant, and the patients remained comfortable and without an implant failure (15). Preliminary reports showed that there is no detrimental effect on denture maintenance, patient satisfaction, implant survival and peri-implant bone loss when the number of implants is reduced from two to one (15, 16). However, the impact of single implant overdenture, based on an assessment from the patient's perspective is critical to reveal whether this treatment truly improves a patient's health status and quality of life. Thus the two outcomes, i.e. masticatory efficiency and patient satisfaction, are crucial aspects of a patient-centred approach to oral healthcare.

The purpose of our study is to access the changes in masticatory efficiency and patient satisfaction of single implant supported mandibular overdenture (SIMO) compared to conventional complete denture (CCD).

The objectives of the study includes the following.

1 Comparative evaluation of masticatory efficiency for edentulous patients with mandibular single-implant overdenture and conventional complete denture.
2 Comparative evaluation of patient satisfaction for edentulous patients with mandibular single-implant overdenture and conventional complete denture.

METHODS

We performed a literature search of published articles in Medline database via PubMed, Google Scholar, Cochrane Central Register of Controlled Trials (Central). We searched for studies in English without time restrictions, search was performed from July 2020 till September 2020, including articles since 1997 up to 2020. reporting on single-implant-supported mandibular IODs. Inclusion criteria were randomized controlled trials (RCT) evaluating masticatory efficiency or patient satisfaction with SIMO and complete denture, prospective studies with before-after comparisons, prospective studies with at least 10 SIMO patients. Studies must include conventional denture wearers as an active comparator (control group), and single-arm prospective studies must assess patients treated with conventional dentures as the baseline treatment, masticatory efficiency or patient satisfaction had to be assessed. Articles selected had to include the search terms either in the title or abstract.

Exclusion criteria were studies in languages other than English, reviews, case reports, abstracts, editorials, letters, studies including animal experiments and historical reviews and *in vitro* studies.

For the search of the studies to be considered for this review, detailed search strategy was developed for the database. Two reviewers independently performed the search (A.Q., P.S.). Combinations of controlled terms (MeSH), keywords and Boolean operators were used whenever possible. Search strategy was similar as that of Nogueira et al. (20) which was further adjusted.

Data Base	Search Strategy
PubMed	(P) #1 (mouth, edentulous (MeSH Terms)) OR mouth, edentulous (Title/Abstract)) OR mouth, toothless (Title/Abstract)) OR edentul*(Title/Abstract)) OR edentulous patients (Title/Abstract)) OR toothless patients (Title/Abstract)) OR jaw, edentulous (MeSH Terms)) OR jaws, edentulous (Title/Abstract)) (I) #2 (denture, overlay (MeSH Terms)) OR denture, overlay(Title/Abstract)) OR overdenture*(Title/Abstract)) OR implant overdenture(Title/Abstract)) OR mandibular overdenture(Title/Abstract)) OR single implant(Title/Abstract)) OR one implant(Title/Abstract)) OR midline implant(Title/Abstract)) OR median implant(Title/Abstract)) OR single implant overdenture(Title/Abstract)) OR single-implant overdenture(Title/Abstract)) (C) #3 (denture, complete (MeSH Terms)) OR denture, complete (Title/Abstract)) OR denture (Title/Abstract)) (O) #4 (masticatory efficiency (MeSH Terms)) OR masticatory efficiency (Title/Abstract)) OR masticatory capacity (MeSH Terms) OR masticatory capacity (Title/Abstract)) OR masticatory performance (MeSH Terms) OR masticatory performance(Title/Abstract)) OR chewing ability (MeSH Terms) OR chewing ability (Title/Abstract)) OR masticatory bite force (MeSH Terms) OR masticatory bite force (Title/Abstract)) OR mixing ability (MeSH Terms) OR mixing ability (Title/Abstract)) OR (patient satisfaction(MeSH Terms)) OR patient satisfaction(Title/Abstract)) OR satisfaction with the denture*(Title/Abstract)) OR patient outcome assessment(MeSH Terms)) OR patient outcome assessment (Title/Abstract)) OR research, patient-centered outcomes(Title/Abstract)) OR outcome assessment, patient(Title/Abstract)) OR patient*reported outcome*(Title/Abstract)) OR patient*centered outcome*(Title/Abstract)) #1 AND #2 AND #3 AND #4
Cochrane Central	(P) #1 edentulous mouth OR toothless mouth OR edentulous OR edentulism OR edentulous patients OR toothless patients OR edentulous jaw (I) #2 overdenture OR implant overdenture OR mandibular overdenture OR single implant OR one implant OR midline implant OR median implant OR single implant overdenture (C) #3 complete denture OR denture (O) #4 masticatory efficiency OR masticatory capacity OR masticatory performance OR chewing ability OR masticatory bite force OR mixing ability OR patient satisfaction OR patient-centered outcomes OR patientreported outcome OR patient-oriented outcome OR clinical effectiveness OR clinical efficacy OR treatment effectiveness OR treatment efficacy
Google Scholar	P) #1 "mouth, edentulous" OR "mouth, toothless" OR edentul* OR "edentulous patients" OR "toothless patients" OR "jaw, edentulous" OR "jaws, edentulous" (I) #2 "denture, overlay" OR overdenture* OR "implant overdenture" OR "mandibular overdenture" OR "single implant" OR "one implant" OR "midline implant" OR "median implant" OR "single implant overdenture" OR "single- implant overdenture" (C) #3 "denture, complete" OR "denture" (O) #4 "masticatory efficiency" OR "masticatory capacity" OR "masticatory performance" OR "chewing ability" OR "masticatory bite force" OR "mixing ability" OR "patient satisfaction" OR "patient outcome assessment" OR "research, patient-centered outcomes" OR "patient-reported outcome*" OR "patient-related outcome*" OR "patientoriented outcome*" OR "patient-relevant outcome*" OR "clinical efficacy" OR "treatment effectiveness" OR "treatment efficacy" #1 AND #2 AND #3 AND #4

TABLE 1 **Description of the search strategy.**

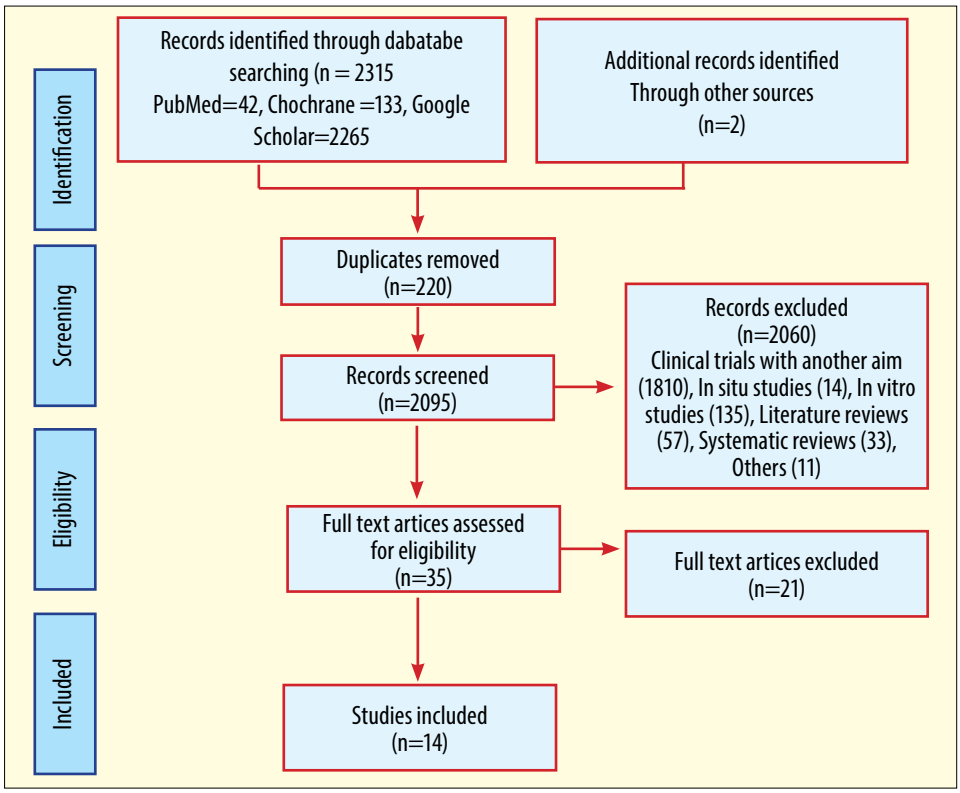


FIG. 1 Study selection process (PRISMA flow chart).

A detailed description of the search strategy is reported in Table 1. The keyword employed in this search was broadly classified in five categories describing population (P), intervention (I), comparison (C), outcome (O). After duplicate records had been removed, two investigators (A.Q., P.S.) independently performed the study selection by initially screening the title and abstract according to the inclusion criteria. Inclusion of articles for the full text analyses was performed only after a mutual agreement between the two; where there was disagreement, it was resolved by means of a consensus discussion presided over by the third reviewer (A.B.). In the case of multiple studies from the same cohort, if the publications reported different outcomes, both studies were included; if the same outcome was reported at different visits, only the study with the longest follow-up period was included. Inter-reviewer agreement was measured through Cohen's kappa. Data extraction was performed independently by the two reviewers (A.Q., P.S.) according to the aims of present systematic review and were reciprocally blinded to each other's extraction. Disagreements between the review authors were discussed and resolved with a third review author (A.B.) The data extracted, comprises the characteristics of the eligible studies which were put into the piloted data extraction sheet in the Microsoft Office Excel 2007 (Microsoft Corporation, USA). Risk of bias within studies was independently evaluated by two review authors (A.Q., P.S.). The Cochrane Risk of Bias Tool for Randomized Controlled Trials (21,22) was used to assess the included trials and therefore studies were classified as low (if all domains were at low risk of bias), unclear (if there was an unclear risk of bias of at least one domain) or high risk of bias (if at least one domain was scored as being at a high risk of bias). The following domains were assessed: Random sequence generation, Allocation concealment, Blinding of participants and personnel, Blinding of outcome assessor, Incomplete outcome data, Selective outcome reporting and Other sources of bias. The Cochrane checklist for describing and assessing patient reported outcomes in clinical trials was used as a guide to assess the quality of the included studies (23). Divergences between the review authors were discussed until consensus was reached. Narrative synthesis was provided for the findings obtained from the studies, mainly focusing on the innervation details, characteristics of participants and outcome assessment. The summaries of intervention effects for each study were provided by calculating risk ratio or standard mean difference. The characteristics of the included trials was analyzed. Possibility of meta-analysis is difficult to predict because this study includes all types of clinical trials, varying interventions and different methodology. But if studies are sufficiently homogeneous in terms of design, intervention, methodology and other characteristics, then probably further meta-analysis can be carried out.

RESULTS

The study selection process followed the PRISMA guidelines for the methodology (Fig. 1). All the titles and abstracts were screened based on the stringent selection

criteria. Subsequently the full texts were assessed independently by the two reviewers. A total of 14 studies over the past three decades met the inclusion criteria for full text reading and all 14 were included for further analysis. All the statistical analyses were performed using the statistical software Review Manager version 5.3 (The Nordic Cochrane Centre, Copenhagen, Denmark).

Fourteen articles were selected from screening of the above-mentioned number of articles by two independent reviewers. Following careful examination, discussion was conducted depending on the selection criteria by the reviewers. Any discrepancies in opinion were resolved by the third reviewer. Ultimately fourteen articles were selected for qualitative synthesis. Studies meeting the inclusion criteria underwent validity assessment and data extraction. The studies that did not meet the inclusion criteria were excluded. The data provided in the selected studies should contain sample size, follow-up period, implant system, its size, retention system, surgical protocol and loading protocol. The data was extracted and recorded under the same headings as mentioned along with the outcomes, namely patient satisfaction, chewing ability, masticatory performance and capacity and mixing ability. The primary outcomes were the assessment of patient satisfaction, chewing ability, masticatory performance and capacity and mixing ability recorded at different follow-up visits. The implant systems used varied from individual studies. Two studies did not report the implant size used in their studes (29,31). When assessed for the surgical protocol whether it was 1-stage (9,11,26) or 2-stage (8,12,14,25,28-32) the former was more common. Studies conducted by Harder et al. (24) and Nogueira et al. (27) had both types of surgical protocol. From the various retention systems that were found to be used, O'ring/Ball attachment was consistently more used. Most of the studies reported following conventional loading as loading protocol with respect to intermediate or early loading.

The outcome assessed were mainly under the domains of masticatory/chewing ability, patient satisfaction, oral health related quality of life (OHrQoL) and oral health impact profile (OHIP).

Out of 14 studies, 8 were conducted in Brazil (25-32), 2 were reported from India (9,12), 2 from European countries (Italy and Germany) (18,24) and one each from Japan (14) and Myanmar (11). A cumulative total of 338 patients were included in the thirteen studies. The study designs were of variety from randomized clinical trial (14,25,26,29), prospective case series (9,12,18,24) and prospective clinical trial (11,27,28,31,32). The time for follow up visits was in variation from 1 month up to 5 years cumulatively. Overall, 12-month follow-up was the most commonly observed interval (25,26,29,31).

Risk of bias within studies

The risk of bias was assessed for RCTs using Cochrane collaboration tool and performed using the RevMan software. Risk of bias was assessed by the two independent reviews for RCTs included in the review and discrepancies were resolved by discussion and appropriate consultation with a third reviewer. The domains for risk assessment were graded as high, uncertain or low risk, based on selection bias (random sequence generation and allocation concealment), performance bias (blinding), detection bias (assessor blinding), attrition bias (incomplete outcome data), and reporting bias (selective reporting). Thus, the overall risk for individual studies were assessed as low, moderate or high risk based on the domains and criteria. The study was assessed to have a low overall risk only if all domains were found to have low risk, and high overall risk if one or more of the six domains were found to be at high risk. A moderate risk assessment was provided to the studies when one or more domains were found to be uncertain, with none at high risk (Fig. 2, 3).

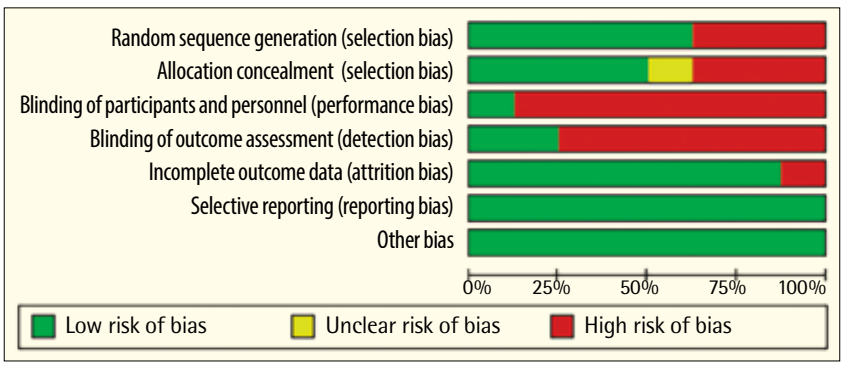
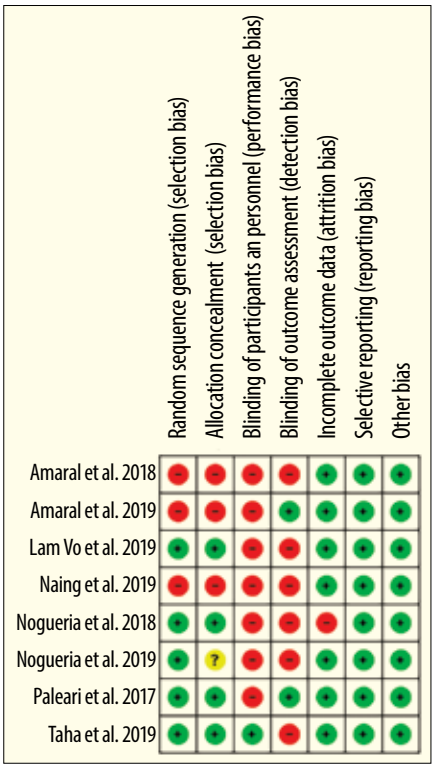


FIG. 2 Risk of bias: review authors' judgements about each risk of bias item presented as percentages across all included studies.

FIG. 3 Risk of bias: review authors' judgements about each risk of bias item for each included study.



The majority of studies reported performance and detection bias in their methodology. Studies conducted by Paleari et al. (25) and Taha et al. (32) had methodology that could be followed in future studies: satisfaction and quality of life, better chewing efficiency and diet consumption, higher stability, changed perspective of patient towards prosthesis and long-term alternative treatment plan. The only drawback reported was a compromise in esthetics, which is ignorable viewing the pros of the intervention. The qualitative synthesis for the primary outcome of masticatory efficiency was assessed with VAS tool (Harder et al.), while color changing chewing gum was another tool of assessment where the participants were instructed to chew the gum 100 times, flattened to a thickness of 1.5 mm and evaluated using a quantitative color scale. Sieve method was another tool through which masticatory efficiency was measured. The best method of assessing patient satisfaction being a subjective phenomenon, majority of the studies in the review did it through questionnaires. The structured questionnaires had subsections on domains namely: general satisfaction, comfort, stability, ability to speak, ability to chew, aesthetics. Both the outcomes were measured at specific time intervals.

DISCUSSION

This systematic review summarized the present literature from clinical studies regarding the impact of SIMO treatment on masticatory efficiency and patient satisfaction (i.e., patient- reported outcomes) after the insertion of a single implant to retain a mandibular overdenture in conventional complete denture wearers. Different studies with varying study designs investigated the concept of the single mandibular implant in the edentulous mandible and found overall high success rates, better masticatory efficiency, high patients' satisfaction and a great improvement of oral health related quality of life when compared to conventional complete denture. However, the masticatory ability results were found to be inconsistent.

Nevertheless, the heterogeneity among primary studies and the absence of randomized clinical trials comparing SIMO with CD may render meaningless any pooled estimate in a meta- analysis. Hence, this review is limited to a descriptive summary of the selected studies that described patient-reported outcomes, as well as an analysis of the main weaknesses and strengths of the methods used for outcome assessment in those studies.

Recently, single implant retained-overdentures have gained popularity and have been reported as a successful treatment concept due to their lower costs and minimal tissue trauma. This treatment modality may have the potential to eventually become the new minimum standard recommended for the compromised elderly edentulous mandible, with the accumulation of more robust evidence for the mandibular single-IODs particularly with long- term outcomes beyond 10 years. The treatment of the compromised elders requires a minimally invasive and an effective approach at the same time. The single-IODs may just provide such a solution in elderly edentulous patients (33). Locker mentioned in 1998, "The ultimate and overriding aim of any health care intervention should be to reduce pain and discomfort, improve function and enhance psychosocial well- being". Additionally, it has been reported that satisfaction is the most important goal for edentulous patients, making it an important outcome to consider (34). Thus, this review reported the masticatory efficiency and patient satisfaction with single implant retained overdenture.

Masticatory efficiency: Mastication is the process of chewing food for swallowing and digestion. It is influenced by many variables for example; dental status, age, gender, denture quality, test food selection, rate of chewing and bite force (35). Masticatory efficiency is defined as the effort required for achieving a standard degree of comminution, while masticatory performance is defined as a measure of the comminution of food attainable under standardized testing conditions (GPT). Thus, masticatory performance is the ability to grind certain portion of food with determined number of masticatory cycles, while masticatory efficiency is related to the amount of chewing necessary to achieve a given degree of grinding of test food, independently of the number of masticatory cycles. However, despite of an attempt to standardize, these terms has been published, there is a lack of authors acceptance to this semantics (36). One goal of dental restoration is to improve the masticatory function of patients who have lost teeth (37). A poor mastication may lead to changes in food selection, thus negatively affecting the orofacial muscle tonus or even the nutritional status. Simple, reliable methods for measuring masticatory function would be useful aids in evaluating the success of dental restorative procedures (37). Masticatory performance has been evaluated by objective measures (masticatory tests) and subjective measures (individual perception). The subjective methods include those instruments intended to gather the patients' or study participants' ratings of their chewing experience and satisfaction (Feine & Lund, 2006) whereas objective measures generally involve bite force, electromyography and ultrasonography of masticatory muscles, masticatory performance determination, among others (van der Bilt, 2011). The individual perception of masticatory performance is often measured by questionnaire. No positive correlation was found between the patients' perceptions of the ability to chew the test food with the masticatory test. Therefore, the self-assessment of chewing ability is not sufficient for evaluation of masticatory performance and also it lacks the necessary objectivity for repeatability and validity. Hence, the subjective and objective assessments, both should be employed in order to better assess the impact

of any dental procedure or the effect of oral impairment on a patient's ability to form a bolus that is safe to swallow. Masticatory function tests have been described by Lehman, Gaudenz, Christiansen, Schutz, Paulsen, Claussen, Balters, Ascher, Gelman, Juul, Ono, Sognnaes and Dahlberg (35). The methods used to determine and analyse masticatory function include: sieving method (gravimetric sieving method, volumetric sieving method, single/multiple sieves), colorimetric determination, optical scanning, ditect photographic measurements, image analysis. A variety of natural (carrot, coffee beans, almond, peanuts, soya beans, boiled white egg, apple, bread, shredded coconut, meat, cracked corn, raisins and cylindrical coconut) and artificial test; materials (Optosil, Optocal, Optocal Plus, CutterSil, chewing gums, irreversible hydrocolloid impression material, gelatin, paraffin wax and mixture of calcium carbonate) are used to determine masticatory performance, measuring the particle size distributions of the food bolus. The use of natural test food was said to cause a lot of variation due to their physical properties such as fracture strength, sizes and shape. Natural food was frequently inhomogeneous and different food preparations might lead to diverse effects in terms of force generation and jaw movement. Artificial test food can be more consistent in terms of size, shape and texture. However, artificial test food with high fracture strength in proportion to the maximum bite force of subjects with fewer teeth (or edentulous) may prevent the measurement of their masticatory performance and efficiency.

In the present review, the masticatory efficiency with SIOD was evaluated using the sieve method, colorimetric determination, bite gauge, and questionnaire. In the reviewed studies, higher masticatory efficiency, chewing ability and communiting ability were observed with SIMO group when compared with CCD group.

Grover et al., Bhat et al., Paleari et al., Amaral et al., Amaral et al. and Naing et al., concluded that masticatory efficiency of single midline implant supported overdenture is better than the conventional complete denture. This finding can be explained as follows.

1) Implants placement, which can increase masticatory muscle activity of patients with edentulous mandible, and improve mastication as a consequence.
2) The better retention and stability provided by a SIO, promoting resistance of the prosthesis against horizontal movements (31).

Harder et al. (24) reported that the central implant-supportedmandibular dentures showed significant improvement in the subjective chewing ability of hard and fibred food. But this finding is in contrast with Amaral et al., who concluded that subjects revealed similar satisfaction with their masticatory ability after using both types of prosthesis (CCD and SIMO) (28).

These opposing data may be explained by methodologic differences between studies.

1) While Harder et al. selected patients already using technically acceptable complete dentures, Amaral et al. subjects were using old and unsatisfactory prostheses (Rise Index degrees II and III), which were replaced by new maxillary and mandibular conventional dentures.
2) The absence of differences in masticatory ability after conventional complete denture and single-implant overdenture use could be because in Amaral et al. study subjects have experienced the greater masticatory ability when their old, unsatisfactory dentures were replaced by the new conventional ones. Consequently, when the single-implant overdenture was used, the subjects continued to be satisfied with their mastication as much as they were with the conventional complete denture.

Vo et al. (14) evaluated the mixing ability and maximum bite force using color changeable chewing gum and occlusal force meter respectively and showed a significant improvement after the new overdenture was attached to a single implant.

However the study by, Nogueria et al. (29) suggested that the use of a conventional denture perform similar to an overdenture retained by single mandibular implant in the 1 year follow- up. He suggested that the conflicting study results might be due to the following reasons.

- Differences in study design: there is little uncertainty about the positive effects of implant intervention in before-after treatment designs. However, parallel-group designs comparing independent groups treated with conventional CD or overdenture may fail to demonstrate significant differences in the long-term, since subjects treated with CD may also show longitudinal improvement in masticatory performance, due to improvement in adaptation to the dentures in follow-up assessments.
- Individual anatomy of CD patients: In a cross-sectional study, Fontijn Tekamp et al. (41) reported that chewing efficiency in edentulous patients with a high alveolar ridge even exhibit better results than patients with implant-supported overdentures.
- The instruments used for the assessment: Comminution tests using different types of test foods and sieve method rely largely on the maximum bite force, as the test food must be hard and breakable. The stabilization of dentures with implants will reliably increase the maximum bite force compared to the baseline measurements with conventional dentures. It is not surprising that studies that reported improved masticatory efficiency in edentulous subjects with implants with respect to conventionally restored patients, using comminution tests, also report combined improvement in maximum bite force.

Mixing ability tests rely on the on the bolus forming and kneading of the test food. These tests rely less on the crushing and comminution of the test food, but more on the bolus forming and kneading. Therefore, these tests are not as dependent on the maximum bite force, as the specimens are more deformable and often soft,

but rather on the force, coordination, and sensitivity of the soft tissues (e.g. the tongue, palate, and cheeks) that are affected by aging itself, diminished capability of adaptation to the dentures and poor mandibular denture retention. These tests often fail to demonstrate a short-term (up to 1 year) effect on chewing efficiency. The mixing ability test was also found to be more appropriate for patients with compromised oral function than the comminution test.

The comparison between the two treatments

All patients received new dentures of acceptable quality and were considered to be fully adapted to the dentures at baseline. This may be a possible explanation to the null overall difference between CD and SIMO groups, and also for the fact that SIMO patients only performed better at the first follow-up after 6 months.

Patient's satisfaction

Clinicians traditionally assess the outcome of dental implant treatment on the basis of clinical parameters such as implant and superstructure survival, marginal bone loss, complications and aesthetics. Economic parameters relate to fabrication and maintenance costs of a prosthesis and can also be objectively evaluated. Psychosocial parameters relate to patient's perception of implant treatment and have gained considerable interest in recent years. Thus, patient's final evaluation should be considered pivotal, even if such assessment is subjective and therefore difficult to quantify. Thus, PROMs have become one of the most used subjective outcomes in clinical researches and a growing interest in PROMs has emerged in the scientific community. Even though the selected studies reported relatively small sample sizes, most of them were powerful enough to detect differences, mainly for within-group comparison of single-group studies. These differences could be detected because of the marked increase in patient satisfaction after SIMO treatment when compared to CD. On the other hand, the small sample sizes limit the ability to test the effect of specific patients' conditions on clinical and radiographic outcomes, and the detection of significant general and local risk factors (20). Besides the wide spectrum of outcome measures in implant and prosthodontic interventions, this review focused on outcomes directly reported by the patient. Patient-reported outcomes include any evaluation obtained directly from patients through interviews, self-completed questionnaires, diaries or other data collection tools such as hand-held devices and web-based forms. The measuring instrument must be standardized and show external validity in order to reduce bias and provide comparable results among different studies. Currently, there is an increasing focus in clinical studies on placing patients at the center of healthcare research and on evaluating clinical care. The goal is to improve the patient's experience and ensure that research is both robust and of maximum value for the use of health interventions and products. Patient-reported outcomes are also suggested to be of more importance in the future compared to any other outcomes (for example, clinical, physiological or caregiver reported outcomes) because patient feedback and change in patient behavior is essential to improve treatment adherence and satisfaction (20).

Treating CCD wearers with implants to retain their dentures led to obvious improvements of patients' satisfaction with their oral status as measured by questionnaires and interviews. In the majority of the studies, IODs were superior to CCDs with regards to efficacy, satisfaction, and quality of life. The currently available evidence suggests increased efficacy for patients treated with IODs when compared to those treated with CCDs. Implant retained overdentures seem to be a more valuable option compared to CCDs for patients seeking to overcome their functional deficiencies. Psychometric and outcome instrumentations varied among the studies, which included the OHIP, visual analogue scale (VAS), and masticatory performance tests.

The articles were reviewed and they reported significantly increased patient satisfaction for the mandibular IOD group compared to the CCDs group. It is noteworthy to mention that a few articles reported that patients who received a CCD were also fully or moderately satisfied with their removable prosthesis. While patient reported satisfaction can be influenced by a variety of factors, the consistent and reliable findings that IODs were associated with higher patient satisfaction ratings provide strong evidence to suggest that patients preferred IODs and experienced subjective outcomes that were superior to CCDs.

Cordioli et al. (18), Carletti et al. (30), Taha et al. (32), Naing et al. (11) found that, patients wearing mandibular SIOs were more satisfied with their prostheses than patients wearing only conventional CDs. Thus, there was remarkable improvement of all symptomatology related to oral discomfort and functional difficulties caused by poor anatomic structure of the mandibular ridges after severe bone resorption and thus, the mean satisfaction level with SIMO was significantly higher than that of conventional mandibular dentures at different time points.

Nogueria et al. (26) and Amaral et al. (28), showed marked improvement in patient satisfaction with SIMO regarding overall score and all items, except for satisfaction with esthetics. Compared with the conventional complete prosthesis, the overdenture has no alteration in its external region of the denture base. However, the intaglio surface of the overdenture can show some metallic components, such as the matrix. Thus, even if the matrix does not appear when the overdenture is in its position in the mouth, the subjects can see this metallic component every time that they insert or remove their overdentures, and this is likely to negatively influence their esthetic perception. Nevertheless, the decrease in satisfaction

with esthetics did not seem to influence the overall satisfaction with the new treatment, which remained high. Therefore, the authors believe that this finding has no clinical relevance and does not influence the success of the single-implant overdenture. In addition, the main complaint about the mandibular denture was the poor stability, and this aspect was improved.

Paleria et al. (25) and Nougueira et al. (27) observed a difference in patient satisfaction at subsequent visits.

Paleria et al. observed a significant improvement in the overall patient satisfaction treated with single implant overdenture in periods of 3 and 6 months with respect to baseline (conventional CDs). However, at 12 months, the patient satisfaction became similar to baseline (25). This finding was in contrast to other studies, which reported satisfaction of subjects treated with MOD supported by one or two implants, and the results were always higher than baseline among participants with conventional CDs. Paleria et al. suggested that the different results might be due to the following reasons.

- Influenced by the attachment: previous studies used retention systems with higher retention force than the one used in this study and, consequently, showed better results for subjects treated with MOD supported by one implant.
- Production of new CDs: new maxillary and mandibular CDs were produced for all participants to normalize the aesthetic and functional parameters of their dentures. Probably, this fact was responsible for high levels of satisfaction at baseline. It is possible to assume that if patients were wearing their old CDs instead of the new ones, the baseline would be lower and the improvement in the satisfaction levels would be more evident.

Nougueira et al. (27) found that, there was a 38.8% mean increase in patient satisfaction with the mandibular denture. Compared to baseline, all other follow-up periods showed higher mean satisfaction values, but no significant changes were observed between the 3-month follow-up and subsequent follow-up periods.

On the other hand, conflicting results were found by Bhat et al. The statistical evaluation showed that there was no significant difference in patient satisfaction when conventional denture was compared with the single implant supported denture (12).

There is a paucity of literature regarding randomized controlled trials on single implant overdentures. From a clinical point of view, the placement of implants in the midline should be approached with a considerable amount of caution, as it has been reported that especially in women there is a risk of injury to the midline lingual canal vessels.

Another potential limit would be that single-midline IODs present an additional degree of freedom as denture kinetics is not limited to a rotation of the denture during occlusal load, clinically evident as a sinking of the posterior denture saddles. Single IODs may be associated with excessive lateral movements especially in case of occlusion with premature contacts. As the occlusion in complete dentures is dynamic and changes during the wearing period, regular remounting and relining of the dentures is therefore recommended. Also, some studies reported denture fracture as a common complication with overdenture (11, 24, 25, 27). Therefore, further studies with more comprehensive assessment of other relevant outcomes associated with implant and prosthodontic outcomes for SIMO should be addressed with long term follow-ups.

Limitations of the study

Some limitations can be acknowledged in this review.

- Most participants were maladaptive CCD wearers who were dissatisfied with less retention and masticatory function, and the unpleasant experience may exaggerate the results of PROMs with SIMO.
- Many confounding factors might compromise the validity of the results and no meta-analysis was conducted.
- PROMs are complex index and no standardized approaches in dentistry are available at present.
- The number of patients followed up to 5 years was also too small to draw a reliable conclusion.
- Instruments and scales used in the studies for evaluating the masticatory efficiency and patient satisfaction varied and no standardization was found.

Implication for research and clinical procedure

More rigorously designed RCTs comparing SIMO and CCD are needed. Standardized approaches of masticatory function and patient satisfaction used for the edentulous patient should be established. Such studies and reports would enable a systematic appraisal and interpretation of results, which could provide sound evidence about the effectiveness of SIMO compared to other treatments and about the improvement of patient-reported outcomes for poorly adapted CD wearers. In clinical practice, SIMO could be carried out for poorly adapted CCD wearers due to higher satisfaction and masticatory function.

CONCLUSION

Within the limitations of this study, the following can be concluded.

A considerable improvement was found with SIMO in masticatory efficiency and patient satisfaction, especially for maladaptive CCD wearers. Single implant retained mandibular overdenture could be an effective alternative treatment option for edentulous patients.

The increased retention and stability are just enough to resist dislodging forces which helps to improve patient's manipulative skill to their mandibular dentures, thus improving masticatory efficiency. This stable mandibular complete denture set the seal on patient's confidence on wearing the denture, resulting in improved patient's

satisfaction.

It helps to resolve the problem of financial constraints on elderly patients, thus can be considered as a cost-effective treatment modality. It could be considered as a future paradigm for treatment of edentulous mandible. Further studies to compare SIMO and CCD designed with standardized measuring protocols, large sample size and long-term follow-ups are indicated to add evidence and support for the indication of SIMO.

Support
Nil

Conflicts of interest
Nil

Permission
Nil

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