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Mandibular single-implant overdenture as an alternative for full-arch rehabilitations: a literature review

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Oral rehabilitation with mandibular single-implant overdentures (SIO) has been characterized as a solution to improve retention and stability of conventional complete dentures (CD). Among the benefits of this therapy, it can be mentioned minimally invasive surgery, simple prosthetic technique, better retention, and significantly reduced costs. However, the application of this protocol in daily clinic is still not widespread. **Aim:** Thus, this study aimed to perform a literature review to address the clinical characteristics of this rehabilitation, when compared to two-implant mandibular overdentures and CD. **Methods:** For this, searches were conducted in the PubMed, Scopus and Scielo databases, considering articles published in English language, without date limitation. **Results:** It was found 243 manuscripts, of which 20 were compatible with the aim of this study after title/abstract reading. The selected papers focused on masticatory muscles function, satisfaction levels and self-reported quality of life, as well as surgical and prosthetic outcomes, such as need of maintenance and repair, costs, and implant failure rates. All evaluated manuscripts showed similar masticatory function and patients' satisfaction with SIO and two-implant overdenture, while results for SIO were greater when compared to rehabilitations with CD. In addition, SIO costs were half of the TIO, and SIO have proven to do not damage the implant, being implant loss close to zero. However, the prosthesis fracture adjacent to the implant was a recurrent clinical outcome, which requires further studies to solve this impairment. **Conclusion:** Thus, it can be concluded that SIO represents an alternative treatment for frail elders or low-income patients, by increasing masticatory function and improving quality of life.

Keywords: Dental implants. Denture, Complete. Mouth rehabilitation. Mastication. Quality of life.

Introduction

The increase in life expectancy is a worldwide phenomenon. The Brazilian elderly population represents almost 15% of the entire population, corresponding to approximately 26 million people. The enlargement of the top of the age pyramid occurs due to advances in medicine[1], improving the autonomy and quality of life of the elderly. Considering that an adequate diet is directly related to greater intake of nutrients, the oral health plays an important role in general health[2], preventing the development of debilitating diseases[3]. Thus, the aging process can be modulated by the masticatory capacity of the elderly[4].

Although public politics have led to the reduction of dental loss, edentulism is presented in approximately 10% of the Brazilian elderly population. Conventional complete dentures (CD) are used to replace aesthetic, phonetic, and a proper mastication. Due to technical easiness and low cost, CD are the treatment of choice for fully edentulous patients[5]. However, due to the physiological process of residual ridge resorption, bone height and thickness[6] might be insufficient to provide optimal retention and stability for this type of prosthesis, which often results in patient dissatisfaction[5].

The use of osseointegrated implants for oral rehabilitation was a landmark, once they provide anchorage to prostheses, restoring retention and stability. According to the McGill Consensus[7], mandibular overdentures retained by two implants in the canine region should be the standard choice for rehabilitating edentulous mandibles. Therefore, CD is currently indicated for specific cases when there is relevant physical and/or financial impairment[7]. Studies have shown[8,9] that the use of a two-implant overdenture (TIO) brings improvements to quality of life and masticatory function, with promising longitudinal results.

Considering that elderly patients may require less invasive procedures, some authors have proposed the use of overdentures retained by a single implant installed in the central mandibular region (SIO)[10]. This protocol is considered simplified, since it has a less invasive surgical technique and easier biomechanics, not demanding parallelism between the implants[11]. Considering that the cost of a TIO is almost twice the SIO[12], this rehabilitation protocol has become notorious for being approachable to low income elderly[13]. Thus, establishing SIO as a standard protocol to rehabilitate edentulous elders could be consolidated as a public health policy of developing countries.

Despite the SIO concept is considered relatively new, several studies seek to compare them with TIO and CD. Thus, the present literature review was designed to compare SIO, TIO and CD rehabilitations regarding functional parameters, self-reported satisfaction and quality of life, and prosthetic/surgical outcomes, such as need for maintenance and implant loss.

Material e Methods

A literature search was conducted to identify articles that evaluated and compared SIO with TIO and/or CD for functional parameters, such as masticatory performance,

chewing ability, maximum bite force, masseter muscle thickness and electromyography; satisfaction with the treatment and quality of life; and prosthetic/surgical outcomes. Randomized, prospective, and before-after studies, conducted in humans and written in English, were included. Literature reviews, case reports and case series were excluded from the analysis.

The PubMed, Scopus and Scielo databases were accessed on July 27, 2018 for search using the terms "[(overdenture) AND (single implant)]". Two researchers independently screened databases and any disagreement between reviewers was solved by consulting a third researcher. In addition, literature reviews were explored aiming to retrieve relevant papers.

Results

Literature search outflow

The search strategy provided 299 citations, of which 53 were overlaps. Thus, 246 citations were evaluated for eligibility, published between 1982 and 2018. A manual search on bibliographic references added 3 further manuscripts for evaluation. After analysis of the title and abstract, 20 studies were selected for full reading and data extraction (Figure 1).

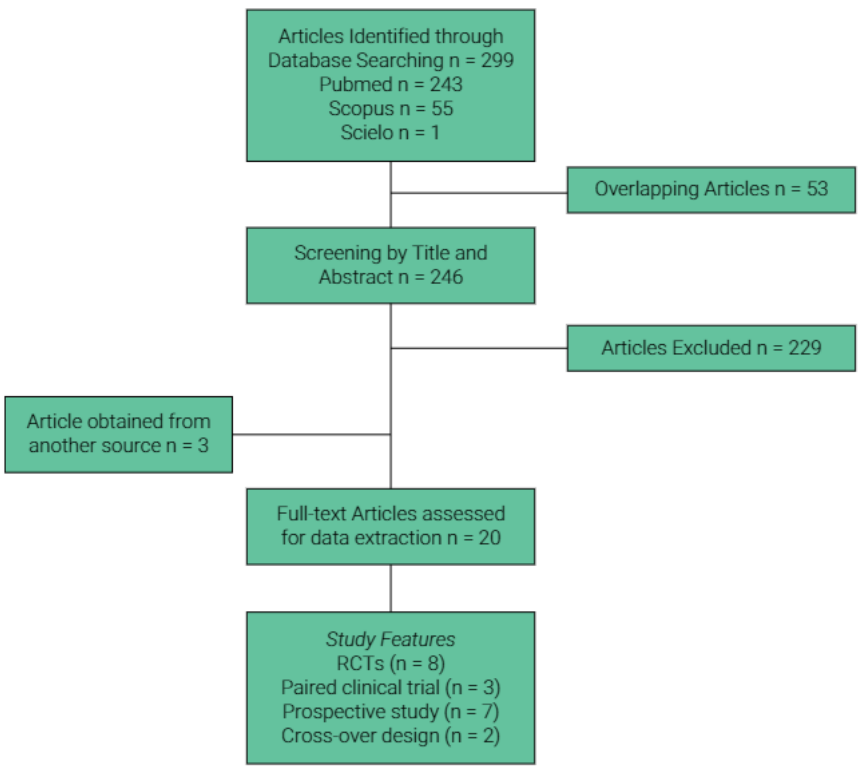

Figure 1. Flowchart of search strategy for the identification of articles.

Functional parameters

Improvements on masticatory parameters provided by SIO were investigated in seven manuscripts[14-20]. There are several methodologies to evaluate the masticatory function, whether subjective, where the patient's perception is the main factor in the measurement; or objective, when it is possible to quantify the improvement in mastication, either by evaluating the chewed material, or by the increased strength and/or tone of the masticatory muscles.

The masticatory ability (MA) corresponds to the perception of how easy or difficult it would be to chew eight foods with different consistencies, hard (bread, apple, meat, carrot and fish) and soft ones (potatoes, mashed potatoes and soup)[14]. Thus, Harder at al.[14] (2011) evaluated the MA of 11 patients rehabilitated with CD and then with SIO, before and four weeks after the overdenture capture. Results showed significant improvement in chewing hard foods, and no differences in the MA for soft foods, once even with the CD patients considered their chewing easy. Conversely, a recent report[15] found no differences in MA after changing from CD to SIO. Authors justified this result because, before data collection, all volunteers received new CD to replace old misfit ones. Thus, considering that MA is related to self-perception, elders were already satisfied with their mastication with the new CD and continued to be satisfied with the SIO[15].

The masticatory efficiency (ME) is an objective method to evaluate the ability to crush foods, in which patients are instructed to chew test materials that will be sifted and weighed. Studies have compared the ME with CD and SIO, demonstrating significant improvement after the implant capture[15-17]. A further approach to evaluate masticatory function is by measuring individual's bite force, in which pressure sensors are positioned uni or bilaterally, and the patient is instructed to bite as strong as possible. The bite force was twice as high in SIO patients when compared to those using CD[18]. In addition, there was no significant difference in such variables when compared to TIO[18].

Electromyography parameters in voluntary muscle contraction and during mastication are also widely used to quantify masticatory function. Thus, efficient muscle activity is characterized by a decrease in electrical potential, since the muscle is able to do the same dynamic by recruiting fewer fibers from the muscle bundles[19]. Thus, a previous study verified a gradual reduction in electromyography values when compared SIO and TIO with CD[19]. However, the TIO promoted greater reduction in the voltage.

Furthermore, greater prostheses retention can be measured by the amplitude of the mandibular movements. This evaluation can be performed by means of a kinesiographic equipment, which can register jaw activity during chewing or bordering movements. Thus, Policastro et al.[20] (2018) evaluated mandibular movements during chewing of patients rehabilitated with mandibular overdentures supported by one or two implants. They observed no difference between the two groups, while both, when compared to the CD, presented higher values of vertical, horizontal and lateral opening after 6 and 12 months of SIO and TIO use.

Satisfaction and Quality of Life

Oral rehabilitation ultimately aims to enable patients' longevity with quality of life. By chewing better, patients ingest more nutrients, contributing to the strengthening of the

immune system and retarding frailty[21]. In addition, higher retention and comfort promoted by using implant-supported dentures, associated with increased self-esteem, improve social life[22]. Thus, satisfaction with the proposed treatment and its impact on quality of life are important factors in treatment success, and were outcomes considered in thirteen of the evaluated studies[10,12-15,17,20,23-28].

Several researchers sought to evaluate, in the short and long term, the psychosocial impacts that rehabilitation with SIO could cause. The first studies have been developed from 1997[10], where, by means of a visual analogical scale (VAS), it was possible to quantify improvements considering comfort and satisfaction after 60 months of SIO use, compared to CD. Other authors also used VAS to evaluate patients complaints[23], general satisfaction, retention, social life/speech, chewing of hard foods, comfort and fit of the prostheses[24]. Improvement in the stability[15], as well as general oral comfort, may be obtained by using SIO. Other studies[12,13,25] compared SIO with TIO, verifying better satisfaction in the transition from CD to overdenture, and found no differences between SIO and TIO. Thus, it was concluded that the number of implants does not influence patients' general satisfaction.

Self-perception of treatments can also be evaluated by means of validated questionnaires, such as the Oral Health Impact Profile (OHIP), whose role is to measure the oral health-related quality of life (OHRQoL). There are several validated versions of this questionnaire: the original, with 49 questions; a summary version, with 14 questions; and a specific for completely edentulous patients, the OHIP-Edent. Scores indicate the individual perception of oral health in a general index and specific domains. Thus, several studies have used some of these scales to compare SIO with CD[14,17,26,27], or to measure their potential against the standard TIO[20,28].

SIO provided significant improvements in all OHIP domains (physical, psychological and social), as well as in general OHRQoL[26,27], with an improvement of approximately 50%[14] when compared to CD. These impacts are especially observed in the first 3 months of prostheses use, remaining constant in the long-term (24 months) reevaluations[26]. Comparisons with TIO showed positive results for both rehabilitations, in order that OHRQoL remained without statistical differences after 36 months of using TIO and SIO[28]. On the other hand, although Policastro et al.[20] (2018) showed an increase in quality of life when using SIO compared to CD, patients with TIO had the greatest gain of OHRQoL.

Prosthetic and Surgical Outcomes

Rates of maintenance, adjustments, and failures in prostheses and implants are considered to be responsible for defining the success of the treatment[29]. These events require additional costs with prosthetic components, laboratory work, and clinical time, making patients dissatisfied with the frequent returns to the dental office. Thereby, eleven studies have sought to quantify possible damages in periodontal tissues[10,25], dentures[11,12,14,24,26,30] and implant[11,19,31,32], caused by SIO use.

Cordioli et al.[10] (1997) evaluated peri-implant parameters in patients wearing SIO for 5 years, and the mean marginal bone loss was compatible with previous literature (1.42 mm + 0.56 mm). Even in the most severe cases, marginal bone loss was lesser

than one-third the length of the implant, keeping it stable after 60 months. Likewise, another study did not identify differences in the peri-implant bone levels of patients using SIO and TIO after 12 months[25].

Studies[11,14,24,26,30] sought to identify possible clinical complications of SIO. The major intercurrence observed was the fracture of the denture adjacent to the matrix, requiring repairs. A fracture rate close to 50% in a 24-month period was observed, and this high prevalence would characterize failing of the rehabilitation[26]. Meanwhile, the most common adjustment in SIO was the replacement or reactivation of the attachment, due to retention loss. In some cases, it was necessary to replace the matrix[11], without the need to substitute the ball-type component[24], since there was no visible wear in the system[24].

Moreover, the loading protocol for SIO was evaluated[31], and patients whom received immediate loading had greater implant loss compared to conventional loading[31]. SIO survival was assessed in periods ranging from 12[19] to 76 months[11]. Randomized clinical trials compared the survival of SIO and TIO, revealing a 100% success rate[19,32], which corroborates with a longitudinal study evaluating SIO for 6 years[11].

Another important outcome to be considered when choosing the best treatment option is the cost-effectiveness of the rehabilitation. The use of SIO and TIO was evaluated during one year considering surgical parameters, prosthetic steps, cost with components and total time spent with treatment[12]. After this period, it was possible to observe that the costs with components were significantly lower for SIO[12]. The authors[12] pointed out that the maximum component cost to manufacture a SIO ($1,123) was lower than the minimum value spent for a TIO ($ 1,419). They also indicated that the median cost of a TIO was almost twice higher than SIO ($1,679 and $957, respectively)[12], demonstrating the feasibility of this treatment for low-income patients. Likewise, the SIO group had significant reduced surgical time to place implants, lower postsurgical maintenance time, and the process to modify the mandibular CD into SIO was faster[12].

Discussion

Currently, rehabilitation with implant-supported dentures is the gold-standard treatment to recover function of complete edentulous patients. Although the McGill consensus[7] defines that the standard protocol to rehabilitate edentulous individuals should consist of TIO[7], there is still no agreement about the number of implants that would provide the best prognosis for treatment success[8]. Regardless of the number of implants and type of prosthetic component used, implant-supported prostheses increase bite force in edentulous patients[33]. Therefore, SIO has been studied as an alternative to reduce treatment costs, maintaining its effectiveness. Several authors[10-20,23-28,30-32] sought to evaluate SIO clinical behavior, by means of masticatory function, patient's satisfaction, and intercurrences with the use of prostheses, such as failures in overdentures, components and implants.

According to the studies included in the present literature review, it was observed that chewing with SIO, measured by objective and subjective tests, had substantial

improvements when compared to conventional CD. A possible explanation for this result is the greater retention of these prostheses, which reduces horizontal movements and denture displacement during function. Thus, retention by osseointegrated implants promotes greater patient confidence in chewing, increasing bite force[18] and, consequently, the ability to comminute food. Patients wearing SIO reported similar masticatory function as those who used TIO.

Improvements in masticatory function could also be reflected in levels of satisfaction. This variable was measured by VAS in eight of the nine papers reviewed, addressing general satisfaction, retention, stability, speech, chewing and comfort levels in patients rehabilitated with SIO[10,24,26]. Therefore, the greater retention provided by installing one implant in the jaw plays an important role in patients' general function, expectation and positive response to prosthetic rehabilitation.

Considering elders with greater alveolar bone resorption, in which conventional CD would not be adequately supported and retained due the lack of anatomical structures, this single mandibular implant enables proper chewing and leads to greater social interaction[34]. These characteristics directly reflect in OHRQoL, also evaluated in this review. The included papers used the original OHIP version (49 questions) and one for edentulous patients (OHIP-Edent). Through the questionnaires, it was observed that the OHRQoL of patients rehabilitated with SIO increased compared to when using conventional CD, and was at least similar to individuals using TIO. Therefore, from the patient's point of view, this treatment option is quite satisfactory, improving function and well-being, which, ultimately, will influence the life expectancy.

High costs and being old-aged are the main reasons for reduced acceptance to implants treatment[35,36]. According to our findings, installing a SIO is cheaper than TIO, enabling this therapy for low-income patients[12]. Moreover, being old-aged implies concerns regarding the surgical intervention. Fear of surgery and postoperative pain/healing is still highly reported by elderly patients refusing dental implants[35,36]. Considering that the surgical procedure to insert a single-implant is less invasive due to the reduced surgical time and flap[19], it allows faster healing and lower postsurgical maintenance time[12].

In order to evaluate the biomechanics of overdentures and implants, *in vitro* and *in silico* studies demonstrated that SIO have a satisfactory behavior, with movements similar to the TIO without increasing tension in the peri-implant bone[37,38]. One study evaluated stress distribution by applying lateral forces, and found a more positive dissipation of forces for SIO, considering the O'ring[39]. In addition, it was possible to observe low stress concentration and uniform distribution around the implant, regardless the type of retention system used in SIO[40]. Laboratory studies results corroborate with the clinical findings of this review, since possible overload in the adjacent bone would lead to greater peri-implant bone loss. In agreement, results of longitudinal follow-ups showed bone remodeling compatible with overdentures supported by two implants[10,25,41], as well as high implant survival[19,31].

Despite SIO use has proved to improve denture retention and masticatory function when compared to conventional CD, and demands lower costs and surgical time than

TIO, this treatment has also some limitations. An important finding of this review was the maintenance rate and overdenture repairs. While maintenance was limited to replacing the rubber/nylon matrix or abutment torque, repairs were primarily motivated by overdenture fracture in the area adjacent to the implant[30]. SIO fracture was observed in all studies evaluating prosthesis survival. Studies indicated that the relief area, made in the inner part of the CD to house the matrix[26], associated with the fulcrum caused by masticatory movements, could lead to microdeformations and subsequent fracture of the denture[42].

Considering that this incidence is characterized as a disadvantage of the treatment, the literature has sought alternatives to minimize the need for prostheses repairs. Grageda and Rieck[43] (2014) described the use of a metallic infrastructure to strengthen SIO, without complications after two years of follow-up. Finite element analyses[38] found that the presence of cobalt-chromium infrastructure reduced stress by nearly 62%, compared to SIO without it (8.7 MPa and 22.8 MPa, respectively). Therefore, considering that the construction of the metallic infrastructure in cobalt-chromium is a simple and low-cost technique[44], its insertion in the SIO would minimize possible fractures and corroborate to enable this protocol in clinical practice.

It is important to emphasize that SIO concept emerged through the necessity to develop an alternative treatment to old-old age patients dissatisfied with the retention of their mandibular CD. Due some physical impairments or reduced budget to afford a therapy with two implants, the SIO could be indicated as a less invasive and low-cost procedure. However, if the elderly is healthy and has enough income, the TIO would be the best option. Additionally, regardless the presence of physical and/or financial handicap, if the elderly is not willing to undergo surgery procedures, the conventional CD is still a good treatment option to replace masticatory function and esthetics. Thus, it is up to the clinician to critically evaluate each patient and choose the treatment that better fit the individual necessities and expectations.

Conclusion

According to the present literature review, it can be concluded that the prostheses retained by one or two osseointegrated implants promote greater comfort and satisfaction, increasing the patients' quality of life. In addition, SIO is a treatment option with lower costs and reduced surgical/prosthetic time, promoting results similar to TIO. However, longitudinal clinical studies aiming to minimizing prosthesis fracture in the area adjacent to abutment are still necessary.

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Conflicts of Interest

None

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