

Review Article

Comparing the functional efficiency of tooth-supported overdentures and implant-supported overdentures in patients requiring oral rehabilitation: A systematic review

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ABSTRACT

The aim of this article is to compare the functional efficiency of tooth-supported overdentures and implant-supported overdentures in patients requiring oral rehabilitation. The comparative quantification of the improvement in functional efficiency is very difficult to assess because of the variations in the study designs like the age of the population studied, the male-to-female ratio, the outcome measures used, the clinical setting in which the implant therapy was provided, oral status of the subjects included and the type of implant therapy provided. In this systematic review, the articles included compared the functional efficiency by assessing the bite force, chewing efficiency, electromyographic (EMG) changes measured by EMG analysis, and patient satisfaction for subjects who have been rehabilitated with either a tooth-supported overdenture or an implant-supported overdenture. This will help the clinicians to better plan the treatment, keeping in mind the long-term prognosis for that particular patient.

Key Words: Functional efficiency, implant-supported overdentures, oral rehabilitation, tooth-supported overdentures

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INTRODUCTION

Old age has been associated with patients exhibiting a highly compromised dentition with regard to number of teeth, periodontal disease, bone loss, and caries; hence, planning for a fixed prosthesis becomes extremely difficult. Edentulism is a debilitating and irreversible condition and is described as “ultimate marker of disease burden for oral health.”^[1] The rate of edentulousness differs much between countries, and it has declined dramatically during the last few decades since it is related to a number of factors, such as socio-economy, tradition, oral health resources, and not only to dental diseases. The overall prevalence

of edentulism is about 16.3% in India among older adults (50 years and above).^[2]

The most common practically approached treatment plan for such patients is the fabrication of a conventional complete denture. In general, the patients are satisfied with the provision of such dentures with about 30% of them having unrealistically high expectation toward the functioning of their dentures.^[3] With continuous use of such prosthesis, the oral functions, nutritional intake, communication,

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and the overall confidence is put at risk of creating psychosocial problems.^[4] The desire of patients to have an intact arch of functional and aesthetically pleasing teeth may pose dentists with various challenges.^[5]

Ledger in 1856 was the first to use natural teeth as an anchorage for removable dentures and aid in stabilization.^[6] In 1950s, the concept of using dentures superimposed on natural teeth was popularized by Rehm, Brill, and Miller which improved the functional efficiency.^[7-9] In 1969, Morrow *et al.* and Lord and Teel came out with various concepts, techniques, and textbooks suggesting the reduction of a few millimeters of natural teeth to support dentures.^[10,11] In 1996, Prieskel gave an elaborative explanation regarding overdentures guiding the dentists about how to approach a case.^[12]

The ultimate goal of maintaining the roots was to prevent alveolar bone resorption, provide better load transfer to the underlying structures, maintain sensory feedback and achieve better stability. Furthermore, the patient feels that he/she is not completely edentulous and thereby improving the psychological aspect also. Mericske-Stern *et al.* in 1994, had come to a conclusion that the tooth-supported overdenture was an effective alternative approach to complete dentures.^[13]

Brånemark *et al.* came up with an idea of a fixed prosthesis on 5–6 implants as a viable treatment for edentulous jaws, and during many years this was the dominating concept with extremely successful long-term results. In the mid-1980s, treatments with mandibular implant overdentures were introduced as being less expensive and less complicated but yet successful.^[14] The level of satisfaction experienced by the patients with severely resorbed mandibles provided by implant-supported overdentures can be compared with the satisfied wearers of conventional dentures with improvement in chewing comfort and better stability.^[15] There have been studies that demonstrate implant-supported overdentures being as efficient as a fixed prosthesis for parameters such as masticatory function and patient satisfaction. The implant-supported overdentures have certain advantages over tooth-supported overdentures as the caries risk is nonexistent and can offer a variety of denture designs. The disadvantages being reduced sensory feedback because of the absence of periodontal receptors and higher costs.^[16]

This systematic review compares the functional efficiency of tooth-supported and implant-supported overdentures in patients requiring oral rehabilitation and come to a conclusion whether the teeth be saved or replaced with implants when both the methods are accessible and acceptable to a patient.

MATERIALS AND METHODS

Protocol and registration

This systematic review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines 2015. The detailed protocol was registered at the National Institute for Health Research PROSPERO International prospective register of systematic reviews under the registration number CRD42021234190.

Focused question

The systematic review aimed to answer the following question: Is there any difference in the functional efficiency in humans who have undergone oral rehabilitation by tooth-supported overdentures and implant-supported overdentures?

The population, intervention, comparisons, outcomes format was used to define a focused clinical question.

- Population/Participants: Humans who have received tooth-supported overdentures and implant-supported overdentures for oral rehabilitation
- Intervention: Humans who have received tooth-supported overdentures
- Comparison: Humans who have received implant-supported overdentures
- Outcome: Functional efficiency of implant-supported and tooth-supported overdentures.

Inclusion criteria

Following studies were included:

- Randomized control trials, case-control studies, cohort studies, systematic reviews, review literature
- Studies must include tooth-supported dentures (control group), and other implant-supported dentures
- Functional efficiency/chewing ability to be assessed.

Exclusion criteria

Following studies were excluded: Reviews, case reports, case series, abstracts, editorials, letters, studies including animal experiments and historical

reviews, *in vitro* studies, studies that were not performed comparing the two groups and incomplete data that did not allow the collection of information.

Information sources

Electronic databases

PubMed/Medline, Google Scholar, and Cochrane Library were searched for studies in English without time restrictions, reporting functional efficiency in tooth-supported versus implant-supported dentures patients.

The last search was performed in February 2021.

Search strategy

Two reviewers independently performed the search (A. K and S. W). Combinations of controlled terms (MeSH), keywords and Boolean operators were used whenever possible. A detailed description of the search strategy is given in Table 1.

Study selection

After duplicate records were removed, two investigators (A. K and S. W) independently performed the study selection by initially screening the

Table 1: Electronic databases and search strategies according to the population, intervention, comparisons, outcome question components

Data base	Search strategy
PubMed/ Google Scholar/ Cochrane Library	(P) #1 (Tooth-supported overdenture OR Tooth-supported overdentures [MeSH Terms]) OR Oral rehabilitation [Title/Abstract]) OR Implant-supported overdenture OR Implant-supported overdentures [Title/Abstract]) Tooth-supported prosthesis OR Implant-supported prosthesis [Title/Abstract]) Overdenture* (I) #2 (Tooth-supported denture [MeSH Terms]) OR Tooth-supported dentures OR Tooth-supported overdenture [Title/Abstract]) OR Tooth-supported overdentures [Title/Abstract]) OR "Tooth-supported prosthesis" (C) #3 (Implant-supported denture [MeSH Terms]) OR Implant-supported dentures OR Implant-supported overdenture [Title/Abstract]) OR Implant-supported overdentures [Title/Abstract]) OR "Implant-supported prosthesis" (O) #4 (Functional efficiency OR Functional efficiencies OR Functional difference OR Functional differences OR Masticatory efficiency OR Masticatory efficiencies OR Chewing efficiency OR Chewing efficiencies OR Bite force OR Bite forces [MeSH Terms]) OR EMG activity OR EMG activities [Title/Abstract]) OR EMG* OR Electromyography* OR "Muscle activity" OR "Muscle activities" OR Biting* OR Chewing* [MeSH Terms] #1 AND #2 AND #3 AND #4 AND free full text AND Randomized controlled trial

Significance of *: To search for all terms that begin with a word, we enter the word followed by an asterisk (*) in PubMed advanced search option. EMG: Electromyographic

title and abstract according to the inclusion criteria. The inclusion of articles for the full text analyses was performed only after a mutual agreement between the two. Where there were disagreements, it was resolved by means of a consensus discussion presided over by the third reviewer (A. Kh). Inter-reviewer agreement was measured through Cohen's kappa ($k = 0.84$).

Data extraction

Data extraction was performed independently by the two reviewers (A. K and S. W) according to the aims of the present systematic review and was reciprocally blinded to each other's extraction. Disagreements between the review authors were discussed and resolved with a third review author (A. Kh). The data extracted, comprises the characteristics of the eligible studies which were put into a customized data extraction form.

RESULTS

Study selection

We followed the PRISMA guidelines for methodology. The study selection process is summarized in Figure 1 (PRISMA flow chart). The total number of hits was 4004. After removing the duplicates, 3469 hits were scrutinized for inclusion in the study. All the titles and abstracts were screened based on the selection criteria. The studies that did not meet the inclusion criteria were excluded. Subsequently, the full text of selected articles was assessed independently by two reviewers. Five articles were selected from screening. Following careful examination, discussion was conducted depending on the selection criteria amongst the reviewers. Any discrepancies in opinion were resolved by the third reviewer. Ultimately, five articles were finalized for further analysis. All the statistical analysis were performed using the statistical software Review Manager version 5.3 (The Nordic Cochrane Centre, Copenhagen, Denmark).

Studies meeting the inclusion criteria underwent validity assessment and data extraction. The data provided in the selected studies contained author, year, region, study design, age, gender, tooth-supported overdenture and implant-supported overdenture, outcome/parameter used and conclusion. The data were extracted and recorded.

The publication year of studies varied from 2000 to 2012. A cumulative total of 172 patients were included in the five studies. The study designs were

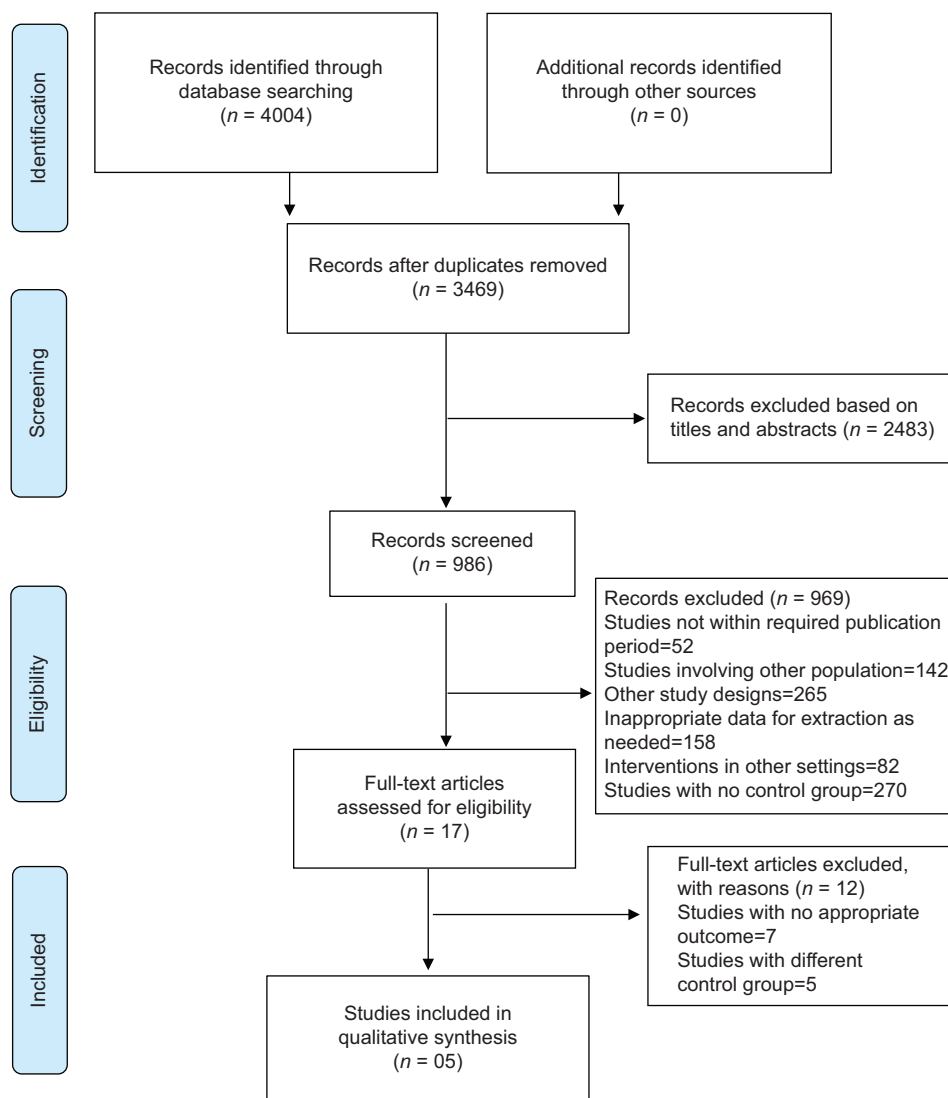


Figure 1: PRISMA flow diagram showing the studies exclusion and final inclusion with reasons. PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

heterogeneous in nature consisting of clinical trials and follow-up studies. The patients' age ranged from 45 to 83 years, covering the various age groups. The male predilection was more as compared to females. Among the lot, three studies did not mention the gender details.

When we assessed for the details about outcome in the patients, the parameters which we assessed were bite force, chewing efficiency, functional efficiency, and patient satisfaction in patients with tooth-overdentures as compared to implant-supported overdentures.

Data extraction items

Tables 2-5 describe primary information that was extracted from the selected articles.

The Risk of Bias in Nonrandomized Studies of Interventions (ROBINS-I) tool was used. The

ROBINS-I tool is composed of three main domains for bias evaluation: preintervention, during intervention, and postintervention.

The risk of bias was overall medium for all the five studies [Table 6].

DISCUSSION

According to the World Health Organization criteria, people with no teeth are considered physically impaired. Edentulous patients could also be considered *disabled*, due to their inability to eat and speak effectively, which are two of the essential tasks of life; they could be considered *handicapped*, as they tend to avoid eating and speaking in public.^[17] Having a functional masticatory system is critical for the

Table 2: Demography related to the included studies

Title	Author	Years	Region
Biting and Chewing in Overdentures, Full Dentures, and Natural Dentitions	Tekamp FA <i>et al.</i> ⁽²³⁾	2000	Netherlands
The masticatory efficiency of Mandibular implant-supported Overdentures as compared with Tooth-supported overdentures and Complete dentures	Chen L <i>et al.</i> ⁽¹⁶⁾	2002	Beijing
Clinical evaluation of 3 overdenture concepts with tooth roots and implants: 2 year results	Hug S <i>et al.</i> ⁽²⁷⁾	2006	Switzerland
Comparison of immediate complete denture, tooth and implant-supported overdenture on vertical dimension and muscle activity	Shah FK <i>et al.</i> ⁽⁴⁾	2012	Udaipur, India
Development of patient-based Questionnaire about aesthetic and Functional differences between Overdentures implant-supported and Overdentures tooth-supported. Study of 43 patients with a follow up of 1 year	Gargari M <i>et al.</i> ⁽²⁹⁾	2012	Italy

Table 3: Study design and inclusion criteria

Author	Study design	Inclusion criteria
Tekamp FA <i>et al.</i> ⁽²³⁾	Clinical trial	Complete maxillary denture
Chen L <i>et al.</i> ⁽¹⁶⁾	Clinical trial	Subjects should be well adjusted to their prosthesis for at least 6 months Adequate retention and stability Adequate denture base extension Satisfactory vertical and centric relationships No need for denture adhesives Absence of inflammation or pathologic lesions
Hug S <i>et al.</i> ⁽²⁷⁾	Follow-up study	Age at least 60 year old Follow-up period of 2 years
Shah FK <i>et al.</i> ⁽⁴⁾	Clinical trial	No signs and symptoms of TMJ dysfunction No systemic disease No history of prosthesis wearing Angle's class I maxillo-mandibular relation At least second premolars on each side acting as bilateral occlusal vertical stoppers Teeth with unfavourable conditions to be extracted Retention of remaining favourable canines
Gargari M <i>et al.</i> ⁽²⁹⁾	Follow-up study	No signs and symptoms of TMJ dysfunction No systemic disease Angle's class I maxillo-mandibular relation At least one premolar or molar on each side acting as bilateral occlusal vertical stoppers Teeth with unfavourable conditions to be extracted

individual to replace the body's nutrients and maintain optimal overall health. To minimize bone loss, chronic

mucosal irritation, and functional problems for the denture patient, provision of tooth-supported complete denture therapy and low-cost dental implant therapies, along with establishment of routine recall systems for these patients, should be the ultimate goal for the dental professional.^[18]

The concept of conventional tooth-retained overdentures is a simple and cost-effective treatment than the implant overdentures. When few firm teeth are present in an otherwise compromised dentition, they can be retained and used as abutments for overdenture fabrication. This helps improve the retention and stability of the final prosthesis significantly. The concept of overdentures may not be the elixir, but it is a positive means for delaying the process of complete edentulism and helps in the preservation of bone. To top it all, it gives the patient the satisfaction of having prosthesis with his natural teeth still present.^[19]

Osseointegrated dental implants revolutionized the conventional prosthodontic treatment. Implant-retained or supported prostheses produce a greater biting force and masticatory efficiency than conventional dentures.^[20]

This systematic review aimed at comparing the functional efficiencies of tooth-supported and implant-supported overdentures.

Carlsson defines masticatory ability as an individual's own assessment of his or her masticatory function, whereas masticatory/chewing efficiency is defined as the capacity to reduce food during mastication or to achieve a certain particle size reduction. Bates *et al.* defined masticatory performance as the particle size distribution of food when chewed for a given number of strokes. Hence, masticatory performance is an objective masticatory function which has often been measured by clinical mastication tests, while masticatory ability is a self-assessed masticatory function studied by interviewing subjects or questionnaires based on their oral function.^[21,22] A total of five articles were shortlisted out of which four studies were clinical trials and 1 was a questionnaire based follow-up study.

Fontijn-Tekamp *et al.* used three parameters namely unilateral bite force, maximum bite force and chewing efficiency.^[23] The bite force was measured using a miniature strain-gauge bite force transducer with a vertical height of 3.8 mm. Subjects were instructed to bite on two force levels: (1) equivalent to force

Table 4: Details of patients included in the study

Author	Average age	Number of patients	Tooth- supported overdenture patients	Implant- supported overdenture patients	Gender
Tekamp FA <i>et al.</i> ⁽²³⁾	59.7 years (tooth – supported overdentures) 58.3 years (implant – supported overdentures)	59	19	40	Not mentioned
Chen L <i>et al.</i> ⁽¹⁶⁾	63 years (tooth – supported overdentures) 57 years (implant – supported overdentures)	28	14	14	Tooth – Supported overdentures Men – 8 Women – 6 Implant – Supported overdentures Men – 10 Women – 4
Hug S <i>et al.</i> ⁽²⁷⁾	69 years (tooth – supported overdentures) 69.2 years (implant – supported overdentures)	32	17	15	Tooth – Supported overdentures Men – 9 Women – 8 Implant – Supported Overdentures men – 7 Women – 8
Shah FK <i>et al.</i> ⁽⁴⁾	53 years (For both groups)	10	5	5	Not mentioned
Gargari M <i>et al.</i> ⁽²⁹⁾	75 years (For both groups)	43	18	25	Not mentioned

Table 5: Parameter used and conclusion

Author	Outcome/parameter	Conclusion
Tekamp FA <i>et al.</i> ⁽²³⁾	Bite force and chewing efficiency	Unilateral bite force – Forces exerted by subjects with dental implants were comparable with root-overlay groups ($P>0.08$) Maximum bite force – Subjects with dental implants exerted significantly higher force than those of root-overlay group ($P<0.004$) Chewing efficiency – subjects with natural roots under their overdentures performed significantly better compared to subjects with dental implants ($P<0.001$)
Chen L <i>et al.</i> ⁽¹⁶⁾	Masticatory efficiency	CME – The CME of implant – supported overdenture group, although not significant, had the tendency of being higher than that of the tooth-supported overdenture group ($P>0.05$) Mandibular excursion – The control of chewing cycles and centralization of end tracings in the cycles of the implant – supported overdenture group were better than those of the tooth-supported overdenture group EMG analysis- Although not significant, patients with tooth-supported overdentures displayed a greater amplitude and integrated value of EMG in temporal muscle than with implant-supported overdentures
Hug S <i>et al.</i> ⁽²⁷⁾	Patient satisfaction through questionnaire using VAS	Patients with implant-supported overdentures rated all questions slightly higher, significantly for the questions regarding general satisfaction, ability to speak, wearing comfort and overdenture stability
Shah FK <i>et al.</i> ⁽⁴⁾	Biting force	EMG analysis No statistically significant difference in masseter muscles' EMG recording in the rest position between both the groups Decreased masseter muscles' EMG activity in tooth-supported overdenture group than implant-supported overdenture group during initial tooth contact position Patients with implant-supported overdentures exhibited greater masseter muscles' EMG activity during maximum voluntary clench than tooth- supported overdentures Maximum biting force – Implant-supported overdenture group experienced greater increase in the maximum biting force than tooth-supported overdenture group
Gargari M <i>et al.</i> ⁽²⁹⁾	Questionnaire based functional efficiency	No statistically significant differences were found between tooth-supported and implant-supported overdentures and the patients show high level of satisfaction for masticatory function, esthetics and phonetics in both the groups.

VAS: Visual analogue scale; CME: Comparative masticatory efficiency; EMG: Electromyographic

they use when chewing and (2) maximum force. The unilateral bite force of implant-supported overdentures was comparable to that of the root-overlay dentures whereas maximum bite force was higher for subjects with dental implants. The possible reason for these differing statistics may be because of the negative

feedback from periodontal receptors as well as painful compression of the marginal gingiva of the remaining roots. However, on comparing the chewing efficiency, the subjects with natural roots under overdentures had a significant edge over the subjects with dental implants. Most of the implant subjects had enough

Table 6: Risk of bias assessment of included studies

Study ID	Bias due to confounding	Bias in selection of participants into the study	Bias in classification of interventions	Bias due to deviation s from intended interventions	Bias due to missing data	Bias in measurement of outcomes	Blinding of the observer	Bias in selection of the reported result	Risk of bias
Gargari A <i>et al.</i> (2012) ⁽²³⁾	No	Yes	No	No	No	No	No	No	Low risk
Chen L <i>et al.</i> (2002) ⁽¹⁶⁾	No	Yes	Yes	Probably Yes	Yes	No	Yes	Yes	Medium risk
Shah F <i>et al.</i> (2012) ⁽²⁷⁾	No	Yes	Yes	Yes	Yes	No	No	Yes	Medium risk
Tekamp F <i>et al.</i> (2000) ⁽⁴⁾	No	No	Yes	No	No	No	No	Yes	Medium risk
Hug S (2006) ⁽²⁹⁾	No	Yes	No	No	No	No	No	No	Low risk

force to pulverize the food but were unable to manipulate it adequately between posterior teeth which led to poor chewing efficiency.

Chen *et al.* compared the masticatory efficiency, mandibular excursions and the electromyographic (EMG) analysis of implant-supported and tooth-supported overdentures.^[16] The mandibular excursions were recorded with a kinesiograph (K5AR, Myotronics Inc., Tukwila, Wash). The tracings were evaluated according to the standard chewing cycle outline of the classification of Ahlgren.^[24] The EMG recording were performed with MEB-5508K EMG equipment (Nihon Kohden Inc., Tokyo, Japan). The masticatory efficiency, control of chewing cycles and centralization of end tracings in the cycles of implant-supported overdenture group, although not significant, had the tendency of being higher than that of the tooth-supported overdenture group ($P > 0.05$). On the contrary, the results showed a greater amplitude of EMG in temporal muscle in subjects with tooth-supported overdentures. Haraldson *et al.* demonstrated that in all masticatory muscles, only the amplitude of the temporal muscle is positively related to occlusal force.^[25] Therefore, it can be inferred that the partly preserved periodontal proprioceptors might be beneficial to the preservation of masticatory muscle function. Slagter *et al.* showed that the peak amplitudes of masticatory muscles in chewing excursions were only slightly related to the reduction in particle size of chewed food.^[26] This suggests that masticatory efficiency is more correlated to mandibular excursions and less correlated to masticatory muscle bioelectric activity.

Hug *et al.* evaluated the patient satisfaction after a 2-year follow-up through a prosthetic questionnaire using visual analogue scale.^[27] All patients were asked

to answer a 9-item questionnaire. The adjustments and repairs of the denture were observed more frequently in root-supported group especially in the 1st year of the prosthesis delivery whereas all 9 questions showed a tendency of higher mean values with implant-supported group. Subjects of the root-supported group were dissatisfied because of frequent dislodgement of copings or activation of female components and some studies indicate a limited prognosis for roots because of their greater susceptibility to caries and periodontal problems. Caries rates of up to 35% were reported even in the presence of a high standard of oral hygiene.^[28]

Shah *et al.* compared the biting force using a force transducer and the EMG activity of the masseter muscle.^[4] No statistically significant difference in masseter muscles' EMG recording in the rest position between both the groups was observed. Decreased masseter muscles' EMG activity in tooth-supported overdenture group than implant-supported overdenture group during initial tooth contact position was recorded. Patients with implant-supported overdentures exhibited greater masseter muscles' EMG activity during maximum voluntary clench and experienced greater increase in the maximum biting force than tooth-supported overdenture group. Patients with tooth-supported prosthesis still had tactile proprioceptive reflex rising from periodontal ligament that alarm them against overload.

Gargari *et al.* developed a patient-based questionnaire about the functional differences between tooth-supported and implant-supported prosthesis with a follow-up of 1 year.^[29] The questionnaire was developed with 6 questions, the themes of which were identified around social, emotional, and practical issues about eating. No statistically significant

differences were found between tooth-supported and implant-supported overdentures and the patients show high level of satisfaction for masticatory function, esthetics, and phonetics in both the groups.

Different oral health conditions may be found with regard to the number of remaining teeth, dental and periodontal health, or type and quality of prostheses. Individual subjective treatment need is based on previous dental experience, self-esteem, self-assessment of general health, mental disorders, mobility, economics, and fear of dental treatment.^[30]

From recent investigations on implant-supported overdentures, one can conclude that this treatment concept is more successful than treatment with overdentures supported by natural roots. Therefore, a final question is posed: shall teeth be saved or instead replaced by implants? Apart from individual wishes and psychologic aspects, namely anxiety of the patients to undergo surgery, strong desire to retain their teeth, previous experience with removable partial prostheses or complete dentures, and predictability of success, some objective differentiations have to be made. More problems with maxillary implants were encountered and reported in various studies: thin bone, loose bone structure, large sinus that does not allow the placement of multiple implants, and divergent implant axes. Force distribution seems to be less favorable with maxillary implants than with fixed prostheses when maxillary dentures are loaded. These observations lead to the conclusion that natural roots should be maintained in the maxillae, preferably if their strategic position is favorable. If maxillary implants are planned for overdenture support in the edentulous patient, support should be provided by four implants with rigid connections. Only minor problems are faced with mandibular implants. Clinical experience gives evidence that two implants provide sufficient support. Therefore, it is advisable to abstain from heroic endodontics and extensive periodontal treatment to save a few remaining teeth. The cost-effectiveness of implants will be more favorable.

CONCLUSION

There have been several studies which have compared the functional efficiencies of conventional dentures with overdentures where it is a proven fact that overdentures have an upper edge over conventional dentures. However, when it comes to comparing the functional efficiencies within the overdenture group

namely tooth-supported and implant-supported, there is very limited literature.

Out of the five articles selected for this systematic review, three were in favor of implant-supported overdentures, one was in favor of tooth-supported overdentures and one showed no statistically difference between the two groups.

Therefore, it is difficult to come to a conclusion as to which one is better than the other.

Nevertheless, the ultimate choice of treatment for the type of prosthesis is based on individual's needs and oral health conditions and the prognosis of the same depends on how well it is being maintained.

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

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