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Literature Review

Survival and Success of Mini Dental Implants Supporting Complete Removable Over-Dentures: A Literature Review

Milisha Chotai[1,2], Sary Rahma[3] and Stefan Abela[2,3]*

[1] Honorary Lecturer, School of Oral and Dental Sciences, University of Bristol, Bristol, Private Practice, Ely, Cambridgeshire, United Kingdom.

[2] Specialty Doctor in Oral and Maxillofacial Surgery, Norfolk and Norwich University Hospitals NHS Foundation Trust, Outpatient Department, West Block, Colney Lane, Norwich, Norfolk, United Kingdom.

[3] Specialist in Orthodontics, Consultant in Orthodontics, Head of Department of Orthodontics Norfolk and Norwich University Hospitals NHS Foundation Trust, Outpatient Department, West Block, Colney Lane, Norwich, Norfolk, United Kingdom.

***Corresponding Author:** Dr. Stefan Abela, Department of Oral Health, Outpatient Department, West Wing Level 2, Colney Lane, Norwich NR4 7UY, United Kingdom.*

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Abstract

Aims and Objectives: To review and report on the literature covering the cumulative survival and success of Mini Dental Implants (MDIs) supporting complete removable over-dentures.

Materials and Methods: An electronic keyword search was carried out using PubMed for Medline (National Library of Medicine, Washington, DC), Google-Scholar, and the Web of Science® interface by M.C. and S.R. The standard and network approaches were utilised according to O'Connor (1992). The initial search was carried out from the 1st of December 2015 to the 31st of March 2016, followed by a second and final search finalised in November 2020. The above -mentioned data bases were searched using combinations of the following key words: *Mini dental implant*, Mini-dental implant*, "Narrow diameter dental implant*", "small diameter dental implant*".* Boolean operators ('Or' and 'AND') were used to expand, exclude and join keywords.

Results: 20 full text articles were analysed. The cumulative MDI survival rate ranged from 66-100% at 1-8.7 years. Success rates ranged from 78-100%

Conclusions: MDI survival rates were found to be lower than those of regular sized implants supporting removable complete over-dentures however success rates of MDIs are high in the short term and offer a very good alternative to regular sized implants. Failures and complications were more prevalent in the maxilla than in the mandible.

***Keywords:** Mini dental implants; immediate loading; edentulous ridges; over-dentures.*

Introduction

Edentulism is the term used to describe the condition of being toothless.[1] This condition remains a major public health concern worldwide, even nowadays, which is especially prevalent amongst older adults. Edentate individuals, with missing teeth or complete absence of teeth in one or both arches, are dependent on complete removable dentures, for basic functions such as speech and mastication, and for aesthetic purposes.[2] Even though there is documentation of decreasing numbers of edentulism, a substantial number of people are still dependent on a removable prosthesis. The World Health Organisation's (WHO) goal of adults retaining at least 20 teeth at the age of 80 years, has not yet been achieved.[1]

Maxillary and mandibular alveolar bone needs stimulation from the periodontal ligaments (PDL) attached to the roots of teeth to maintain its form and density.[3] The loss of teeth results in decreased stimulation to the bone with a consequential decrease in bone volume, width and height.[4] This process is continuous and affects the mandible four times more than the maxilla.[5] Other anatomical consequences of edentulism include; decreased neuromuscular control, increased tongue size, increased fracture risk and thinner soft tissues that are more prone to abrasion injuries.[3]

Bite forces are significantly reduced in the edentulous jaw due to the absence of PDL receptors and the replacement of these by mucosal and periosteal mechanoreceptors together with intra osseous nerve endings.[6] Decreased bite forces will in turn compromise the ability to chew hard and chewy foods.[3]

The psychological consequences of total edentulism can range from very minimal to a state of neuroticism.[3] Edentulous individuals may avoid participation in social activities because they are embarrassed to speak, smile, or eat in front of others, leading to isolation as well as poor oral health related quality of life.[2]

Current evidence suggests that the restoration of the edentulous mandible with a conventional denture is no longer the most appropriate first-choice prosthodontic treatment.[7] The McGill and the York consensus statements both state that an implant supported denture should be the first line of treatment.[7,8] A denture supported by dental implants will be more comfortable and stable than a conventional denture.[9] Multiple studies have shown that implant retained overdentures significantly improve quality of life in patients, [9–11] however, this is not always possible with conventional implants due to certain anatomical limitations.

Dental implant survival is usually described as 'implants in situ'.[3] Buser et al., proposed a classification for implant failures, in which failures are categorised depending on the reason for failure. Table 1 describes this classification. [12]

Table 1: Classification of Implant failure (Buser et al., 1990).

Classification of Implant Failure
Due to recurrent peri-implant infection
Due to implant mobility
Due to implant fracture
Due to progressive bone loss without clinical signs of a peri-implant infection

The definition of 'dental implant success' is not easily obtained, due to the definition of success being so varied and subjective in nature. This can range from being being assessed as healthy and orally viable to being affected by pathology with the most prevalent condition being peri-implantitis or exhibiting increased mobility or unable to support a prosthesis .[3] Implant survival by itself is no longer considered an acceptable criterion to evaluate an implant system.[3] Implant success criteria have been proposed by several authors. Albrektsson et al., provided one of the earliest reports on success criteria specifically designed for dental implants.[13] Since this aforementioned report on implant success there has been significant improvements in dental implant designs and surface treatments, which have resulted in an increased long-term treatment success. Additional criteria such as aesthetics, prosthodontic parameters and patient satisfaction have also been introduced as an essential part of 'implant success'.[14] Listing the parameters in a chronological order of importance is difficult as they cannot be directly compared to each other. To date, there have been no universal consensus statement on the definition of dental implant success. Tables 2-4 below describe the different criteria available for assessing dental implant success.

Table 2: Implant success criteria (Albrektsson et al., 1986).

1	Absence of clinical mobility
2	No radiographic evidence of peri-implant disease
3	<0.2 mm bone loss annually after the first year of service of the implant
4	Absence of pain, infections, neuropathies, paraesthesia or violation of the mandibular canal
5	85% success rates at 5 years and 80% at 10 years as a minimum

Table 3: Implant success criteria (Buser et al.,1990).

1	Absence of persistent complaints (pain, foreign body sensations and/or dysesthesia)
2	Absence of a recurrent peri-implant infection with suppuration
3	Absence of mobility
4	Absence of a continuous radiolucency around the implant

Table 4: Implant success criteria (Papaspyridakos et al., 2012).

Success criteria	Variables
Implant level	Pain, Bone loss at 1st year <1.5 mm, Annual bone loss <0.2 mm thereafter, Radiolucency, Mobility, Infection
Peri-implant soft tissue	Probing depth > 3 mm, Suppuration, Bleeding, Swelling, Plaque index, Width of keratinized mucosa >1.5 mm, Recession
Prosthetic level	Minor complications (Chair side approach), Major complications / failures, Aesthetics, Functional
Patient satisfaction	Discomfort/Paraesthesia, Satisfaction with appearance, Ability to chew, Ability to taste, General satisfaction

Mini dental implants (MDIs) are small-diameter implants with diameters of less than 3mm, made of the same biocompatible material as conventional dental implants.[15] They have been proposed as a minimally-invasive alternatives in patients where placing regular diameter implants would require bone grafting.[16] MDIs were originally used for transitional and provisional purposes, but it was observed that they appeared to osseointegrate.[17] They are approved by the food and drug administration for long-term prosthesis stabilisation. [18]

The purpose of this study was to assess the survival and success rates of MDIs supporting removable over-dentures in edentulous ridges.

Methodology

A thorough electronic keyword search was carried out using PubMed for Medline (National Library of Medicine, Washington, DC), Google-Scholar, and the Web of Science®. Identification, screening, eligibility and quality assessment were performed by two authors, M.C. and S.R. independently. Any disagreements were resolved by discussion with the third author S.A.

The standard and network approaches were utilised according to O'Connor (1992). The initial search was carried out from the 1st of December 2015 to the 31st of March 2016, and a secondary search was carried out in November 2020.

Search

Data bases were searched, using combinations of the following key words: *Mini dental implant*, Mini-dental implant*, "Narrow diameter dental implant*", Small diameter dental implant*.* Boolean operators ('Or' and 'AND') were used to expand, exclude and join keywords (Ely and Scott, 2007). All articles from the search results were firstly narrowed down by reviewing of their title and abstract. This was followed by full text reviews applying the eligibility criteria, to yield the final included studies.

A list of inclusion and exclusion criteria have been applied during the searches and are listed below;

Inclusion criteria

- Descriptive and interventional studies.
- Studies published up until October 2020.
- Human clinical (*in-vivo*) studies.

- Implants with a width of less than 3 mm.
- Treatment interventions in edentulous arches only.
- Study participants had completed growth.
- MDIs used to support complete removable over-dentures.

Exclusion criteria

- In-vitro or lab studies
- Animal studies
- Study participants with dento-facial anomalies (cleft palate, ectodermal dysplasia, trauma, cancerous pathology)
- Studies combining MDIs with implants wider than 3 mm.
- Less than 12 weeks follow up.
- Articles published in non-peer reviewed journals.

No restrictions were made with regards to the gender of study participants. Similarly, no restrictions were applied based on the participants' medical history, dental history and social habits other than those already present in the individual articles.

Results

Electronic database search yielded 107 in the initial search and 26 studies in the secondary search, a total of 133 (Figure 1). The titles and abstracts were further analysed which resulted in a total sample of 43.

Eligibility criterion was applied to the 43 full text versions. The eligibility criteria for each study were analysed in order of importance, and the first 'no' response was used as a primary reason for exclusion of the study without applying further remaining criteria according to Higgins and Green (2011).

The current search strategy yielded a final search result of 20 full text articles.

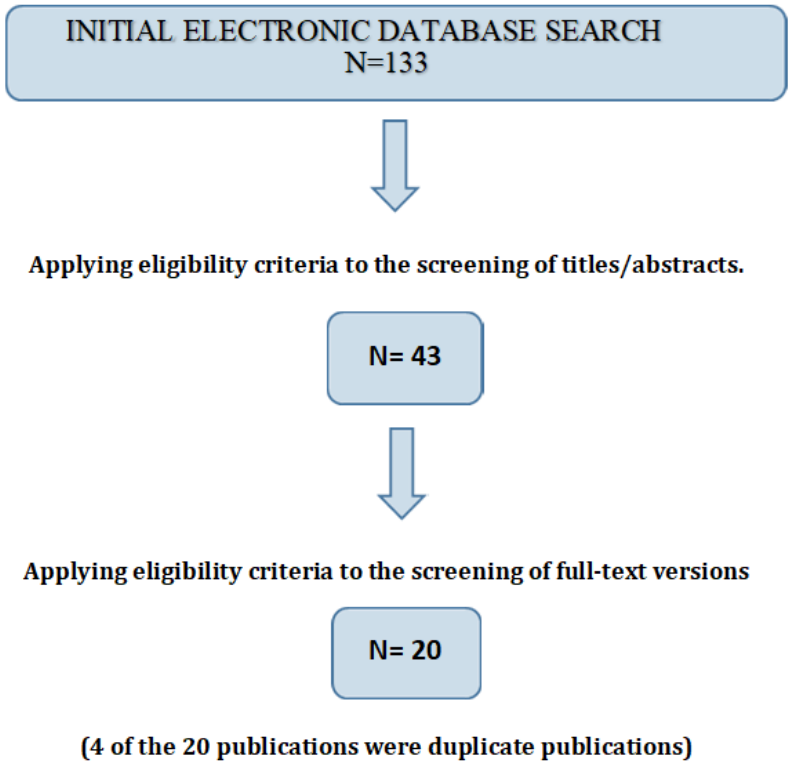

Figure 1: *Search strategy and results for the literature review.*

A total of ten studies included fully edentulous participants in both the mandibular and maxillary arches, [19–27] and in six of these studies, participants were provided with conventional full dentures in the opposing arch. One study by Preoteasa et al., [28] was excluded as there was no documentation on the restorations in the opposing arch.

Eight studies did not specify the participants dental status in the opposing arch. None of the studies reported the reason for their included participants' edentulism.

Site under investigation

Sixteen studies treated the mandible with MDI supported over-dentures. Three studies [28–30] treated both the mandible and the maxilla, and one study[31] treated the maxilla only.

Number and characteristics of MDIs

IMTEC Sendax MDI™ (3M ESPE) was the most common MDI brand; it was used in thirteen studies.[17,19,20,22,23,27–29,31–34] Other implant systems used were Atlas® Denture Comfort MDIs,[30,35] Osstem MDIs,[24] Mini-Drive lock MDIs,[25] Komet® Microplants,[26] PW Plus MDI[36] and Dentium Slimline system.[27,37]

Observation periods

Observation periods ranged from 1 year to up to 8.7 years. Observation periods were defined as commencing on the day of MDI loading in all of the studies. Three studies did not specify the length of follow ups for each individual participant.[17,28,31.]

Surgical and loading protocols

Twelve studies used a flapless protocol when placing MDIs. *Scepanovic et al's studies in 20*12 and 2015 used a combination of flap and flapless surgery, which was based on a clinical parameter.[22,23] In three studies,[24,33,34] flaps were raised whilst placing the implants. Preoteasa et al's study did not provide details on the surgical protocol; it was unclear if a flapless procedure was undertaken.[28]

In all the studies except those carried out by Desouza et al's and Kovacic et al's study, the MDIs were loaded immediately.[37,38]. Preoteasa et al's study failed to report on the loading protocol for the investigation.[28] In all studies, the MDIs were loaded with over-dentures that were adjusted to host the MDI attachments immediately after placement.

MDI Survival and Failures

MDI Survival

Different MDI survival criteria were stated in all studies that reported on MDI survival rate. Fifteen studies defined MDI survival as the total number of MDIs in situ at follow up. The cumulative survival at one year ranged from 80% to 100% [30,39] The cumulative survival at three years ranged from 66% to 100%.[31,34] The details of the studies including cumulative survival rates, arch or arches involved, survival criteria and follow-up period are tabulated in Table 5 below.

Table 5: Cumulative survival rates of MDIs in the included studies.

Study (Year)	Cumulative survival rate	Investigated Arch	Survival criteria	Follow up (Years)
Griffitts et al. (2005)	97.4%	Mandible	Implants in situ	1
Cho et al. (2007)	94.10%	Mandible	Implants in situ	1.2 – 3
Morneburg & Proschel (2008)	95.50%	Mandible	Implants in situ	3.3 -8.7

Table continued….

Jofre et al. (2010)	94%	Mandible	Implants in situ	2
Elsyad et al., (2011)	96%	Mandible	Implants in situ	3
Scepanovic et al. (2012)	98%	Mandible	Implants in situ	1
E.Lsyad et al. (2013)	66%	Maxilla	Implants functional	2
Jofre et al. (2013)	100%	Mandible	Implants in situ	1
Tomasi et al. (2013)	80%	Mandible, Maxilla	Implants in situ	1
Preoteasa et al. (2014)	92.70%	Mandible, Maxilla	Implants in situ	3
deSouza et al. (2015)	85.5%	Mandible	Implants in situ	1
Elsyad et al., 2015	-	Mandible	-	5
Kumari et al. (2015)	NS	Mandible	NS	3.5
Mundt et al. (2015)	95%	Mandible, Maxilla	Implants in situ	4
Scepanovic et al. (2015)	-	Mandible	-	1
Aunmeungtong et al. (2016)	100%	Mandible	NS	1
Zygogiannis et al. (2017)	98%	Mandible	Implant in situ	1
Park et al (2018)	97.2%	Mandible	Implant in situ	1
Enkling et al (2019)	100%	Mandible	Implants in situ	5
Kovacic et al (2019)	93.8%	Mandible	Implants in situ	1

Abbreviations: - = Not investigated, NS= Not specified

MDI Treatment Success

Eleven studies reported MDI treatment success, which was described at an implant level and/or at prosthesis level. Treatment success, at implant level, was most commonly described with the criteria proposed by Albrektsson et al.,[13] Treatment success at prosthesis level was defined as 'prosthesis survival' and 'functional prosthesis'. Four studies *(Scepanovic et al., 2012 and 2015, Kovacic 2019 and Enkling 2019)*[22,23,34,37] used the criteria proposed by Buser et al.[12] to describe treatment success at both MDI level and prosthesis level.

Cumulative success rates ranged from 78% (at three years) to 100% (at five years). Table 6 shows the cumulative success rates with success criteria in the included studies.

Table 6: Cumulative success rates and success criteria in the included studies.

Study	Cumulative success	Observation period (Years)	Success criteria
Griffitts et al. (2005)	-	1	NS
Cho et al. (2007)	100%	1.2-3	Prosthesis survival
Morneburg & Proschel (2008)	NS	3.3-8.7	Albrektsson et al., 1986
Jofre et al. (2010)	NA	2	NA
Elsyad et al. (2011)	92.9%	3	Albrektsson et al., 1986
Scepanovic et al. (2012)	100% Prosthesis, 98.3% MDI Success	1	Buser et al., 1997
E.Lsyad et al. (2013)	NS	2	Albrektsson et al., 1986
Jofre et al. (2013)	-	1	-
Tomasi et al. (2013)	-	1	-
Preoteasa et al. (2014)	78%	3	Albrektsson et al., 1986
deSouza et al. (2015)	100%	1	Functional prosthesis
Elsyad et al. (2015)	-	5	-
Kumari et al. (2015)	100%	3.5	Functional prosthesis
Mundt et al. (2015)	-	4	-
Scepanovic et al. (2015)	NS	1	Buser et al., 1997
Aunmeungtonget al. (2016)	100%	1	Consensus conference of the International Congress of Oral Implantology, Pisa, Italy 2007
Zygogiannis et al. (2017)	91%	1	Albrektsson et al., 1986
Park et al (2018)	97.2%	1	Albrektsson et al., 1986
Enkiling et al (2019)	100%	5	Buser et al., 1997
Kovacic et al (2019)	93.5%	1	Buser et al., 1997

Abbreviations: - = unable to make conclusion about success rate, NS=Not specified, NA= study did not investigate treatment success.

Complications

The types of complications reported in the included studies were divided into; "MDI-related", "prosthesis-related" and "other complications". These are shown in Figure 2. Eleven studies reported complications related to treatment. One study by Kumari el,[24] had no complications at 3.5 years after prosthesis delivery. Five studies,[17,19,27,34,35] did not report on complications, nor mentioned the presence of any adverse events related to treatment.

The most common "prosthesis related" complications included; wear and damage to O-rings, over-denture fractures and soft tissue trauma. MDI related complications included; implant fractures, biological complications such as peri-implant bleeding and lateral bone-wall perforation during implant placement.

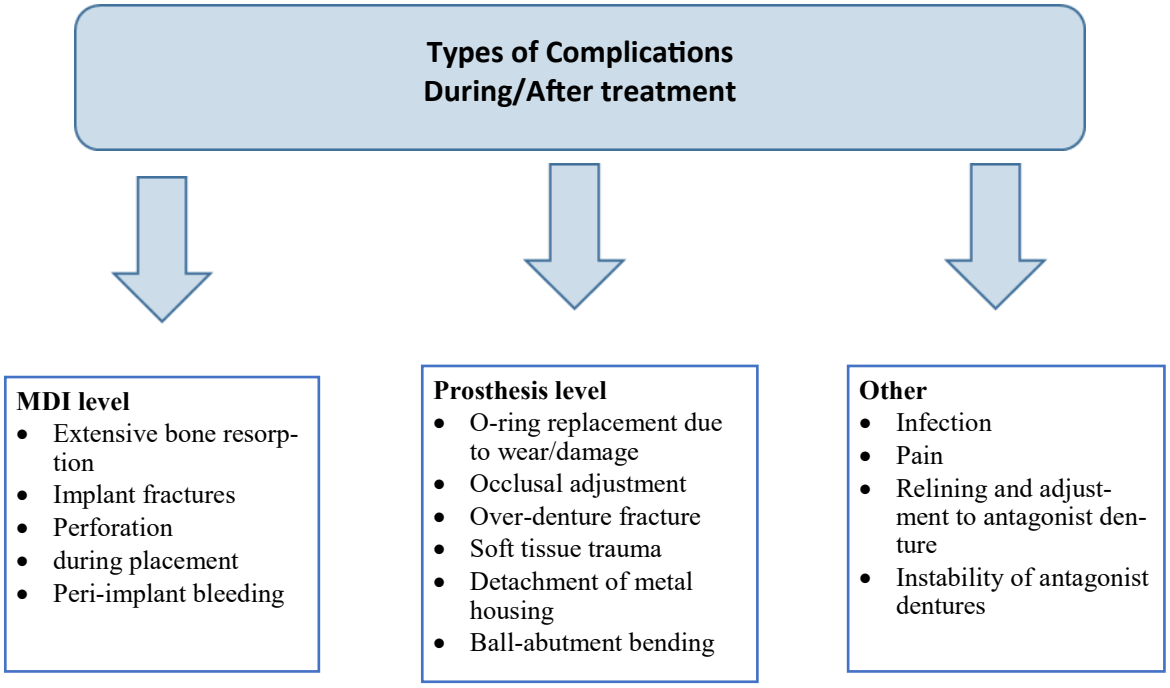

Figure 2: *Categories of reported types of complications in the included studies.*

Discussion

Survival and Failure

18 studies assessed the survival and failure of MDIs which was 66%-100% at three years. Survival criteria differed between studies; it was described as "implants in situ", in 15 studies, and "functional implants" in one study. The lowest survival rate (66%) was found in the study by Elsyad et al that described survival as "functional implants".[31] It can be argued that implant function is more appropriately included in the description of implant success; a surviving implant is not necessarily functional as it may continue to support the other remaining implants. It may therefore be concluded that the low survival rate of 66% in one study is not necessarily a valid result, but instead, related to the authors' definition of "implant survival".

The survival rate of MDIs was found to be lower than the survival rate of regular diameter implants supporting removable over-dentures, except in the study by Enkling et al, who reported 100% survival rate after 5 years.[34] Elsyad & Khirallah found a survival rate ranging from 93%-100% for regular diameter implants supporting removable over-dentures.[40] DeSouza et al also found that the survival rates of MDIs supporting over-dentures was lower than for regular diameter implants supporting over-dentures.[25]

Implant failure was reported in thirteen studies, and it was defined as "implants lost at follow up". Overload was commonly described as a reason for implant failure, and most of the failures occurred in the maxilla. Failed implants were selectively replaced, something that has been shown to be a feasible option as long as the risk factors are modified and controlled.[41]

The increased failure rate of MDIs in the maxilla is comparable to failure rates associated with regular sized implants. Balaguer et al., found a significantly higher failure rate in the maxilla as compared to the mandible. [42] Poor bone density, as well as a less than ideal angulation of implants, has been described as reasons for the increased failure rates in the resorbed maxillae.[30]

MDI treatment success

Eleven studies reported on treatment success, which was described at implant level (using the criteria proposed by Albrektsson et al., and/or at prosthesis level (using the criteria proposed by Buser et al., [12,13] None of these studies had long-term follow ups; longer than 5 years.

The success rates ranged from 78%-100% at 3 years, which is comparable to regular diameter implants supporting over -dentures.[43] Reduced success rates were more common in the studies that described MDI success at "implant level". Peri-implant soft tissues, patient satisfaction outcomes and aesthetic outcomes, were not assessed as a part of MDI treatment success measures.

The success rates were lower in studies that described success at implant level than for studies describing success at prosthesis level.

The outcome measures for MDI success included standardised peri-apical radiographs, panoramic radiographs, peri-implant probing, and periodontal testing. The reliability and validity of these outcome measures is questionable as most studies only carried out these tests once, making the interpreting these results difficult. Outcome measurements were also subject to reporting bias.

Panoramic radiographs in particular, have several drawbacks including poor image resolution, unpredictable image distortion of bone adjacent to implants, limited quality in anterior mandible due to over projection of the vertebra, and difficulty of standardisation.[44] It might therefore be not necessarily a valid outcome measure for the assessment of peri-implant bone levels.

All studies that reported implant success conducted perio-test measurements, most of them on single occasions. Low perio-test values indicate successfully integrated implants; however, single readings are of limited clinical value. There should ideally be at least two sets of readings to indicate progressive osseointegration.[45] The reported perio-test values were similar to those of small-diameter implants, but higher than those reported for standard diameter implants in the anterior mandible.[46] It was not reported if peri-implant probing was undertaken with a plastic or metal probe. Reliability of peri-implant probing is questionable, as the results are dependent on the operator's probing force and the nominated reference point of probing.

Complications

Few of the reviewed studies reported on biological and technical complications in detail. The percentage of patients totally free of complications was rarely reported. Outcome criteria were not specified to define types of complications and so there is a risk of selective reporting bias. Frequently reported complications included damage to O-rings, over-denture fractures and soft tissue trauma. This is in line with investigations on regular sized implants supporting removable over-dentures.[47]

Conclusions

This review found that MDI supporting over-dentures is a treatment of high success and survival rates in the short and mid-term. The success of MDI over-denture treatment is in the short term comparable to treatment involving over-dentures supported by implants of regular diameter. The survival rate of MDIs was found to be lower than the survival rate of regular diameter implants supporting over-dentures. Maxillary MDIs had a significantly lower survival rate than mandibular MDIs, which is also in line with research on regular diameter implants.

Both MDIs and regular diameter implants supporting over-dentures have a higher risk of failure and complications in the maxilla. Treatment complications did not result in significant patient morbidity, with the most common complications being reported at prosthesis level. The type and frequency of prosthetic complications can be compared to over-dentures supported by regular diameter implants.

The results from this review should be viewed with caution due to the lack of validity in studies. The investigations were not appropriate for ascertaining causality and are not transferable to conditions which are commonly found in the patient population that is most likely to benefit from MDI over-denture treatment.

The outcome of this review has highlighted the need for more robust clinical studies on the survival and success of MDIs.

Author Contribution

Author 1: Concept and Design, Research and Data Analysis

Author 2: Data Interpretation and Manuscript Draft

Author 3: Critical Revision of Manuscript and Submission

Conflict of Interest

The authors of this article do not hold any financial interests nor connections (direct, or indirect) and there is no risk of bias in the work reported or the conclusions, implications or opinions stated. There are no commercial or other sources of funding for any of the authors or for the associated department, personal relationships, or direct academic competition.

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