Marginal bone loss 1 year after implantation: a systematic review for fixed and removable restorations

This article was published in the following Dove Press journal:
Clinical, Cosmetic and Investigational Dentistry

Jennifer Zimmermann¹
Melanie Sommer¹
Leticia Grize²,³
Stefan Stubinger¹
¹Hightech Research Center, Department of Biomedical Engineering, University of Basel, Basel, Switzerland; ²Swiss Tropical and Public Health Institute, Basel, Switzerland; ³University of Basel, Basel, Switzerland

Abstract: This systematic review analyses the difference of the mean marginal bone loss (MBL) 1 year after implantation depending on the fixation of the restoration. 889 publications on controlled clinical trials were identified, and based on inclusion and exclusion criteria, 22 studies were selected. Related to fixed restorations, the lowest MBL was 0.05±0.67 mm and the highest 1.37±0.5 mm. The MBL for removable restorations ranged from 0.13±0.35 mm to 1.03±0.65 mm. Three studies analyzed the MBL around implants of overdentures in the lower jaw. The estimate for this restoration type was 0.476 mm (95% CI: −0.305 to 1.258). 19 randomized controlled studies dealt with restorations which were fixed to the implants. The estimate for the mean MBL was 0.459 mm (95% CI: 0.325–0.593). There was a decrease in 1-year implant survival with an increase of 1 mm MBL (−0.083%; 95% CI: −0.179 to 0.0123; p=0.083) in fixed restorations. The difference in MBL between fixed and removable restorations was 0.363 mm (95% CI: −0.319 to 1.044; p=0.279). This systematic review indicates that implants with fixed and with removable restorations lead to comparable MBL.

Keywords: dental implants, marginal bone loss, fix and removable restorations, systematic review

Introduction
Edentulous patients using a conventional prosthesis suffer the loss of mastication, articulation and insufficient retention. Furthermore, this problem causes pain, loss of soft-tissue support and general dissatisfaction.¹ Masticatory efficiency is restricted to people in possession of complete dentures, namely <20% of the masticatory performance compared to those with natural dentition. One option to overcome this issue is the use of endosseous implants.² An established frequently used therapy enables the attachment of the dental implant with a denture.³ Van Blarcom⁴ defined dental implant as

A prosthetic device made of allo-plastic material(s) implanted into the oral tissues beneath the mucosal or/and periosteal layer, and on/or within the bone to provide retention and support for a fixed or removable dental prosthesis; a substance that is placed into or/and upon the jaw bone to support a fixed or removable dental prosthesis.

By connecting the overdenture to the dental implant, the oral health-related quality of life (OHRQoL) improves as well as the masticatory forces increase.⁵
The removable fixation of an overdenture on two implants either splinted or unsplinted is a worldwide accepted medical treatment proven by long-term studies. Selim et al conclude in their review that the patient satisfaction of implant-supported fixed prostheses in the mandible is higher compared to the implant-supported removable overdentures. In contrast, implant-supported removable overdentures in the maxilla reach higher scores than the implant-supported fixed prostheses. The following factors are discussed: esthetics, stability, mastication performance, and pronunciation. In addition to keeping the prosthesis clean, implant-supported removable overdentures in the maxilla and mandible show favorable results. Strietzel et al check the implant loss of many different types of restorations, for example, single-tooth replacement, fixed partial denture, removable partial denture and overdenture. There is no statistically significant difference between the various types of restorations with respect to implant loss. For this reason, it is important to choose carefully which restoration is the most beneficial for the patient. Therefore, the clinician has to consider many factors before starting treatment, such as expenses, amount, arrangement and implant location, existing bone quality and quantity, maxilla–mandibular relationship, condition of the opposing dentition and time frame.

To date, there is little evidence about the relation between marginal bone loss (MBL) and implant-supported fixed or removable prostheses in medical publications. This systematic review was conducted to evaluate the outcome of the mean MBL, implant and prosthesis success 1 year after implantation depending on the fixation of the restoration.

Materials and methods
The present review and meta-analysis were performed according to the PRISMA guidelines. To define the research question clearly and to facilitate the process of performing the review, the PICOS approach was used. This approach is based on five components: population, interventions, comparator, outcomes and study design. The specific components for this review are:

- P (Population): patients need at least one implant
- I (Interventions): fixed-removable restorations
- C (Comparator): the comparator groups were unattended
- O (Outcomes): mean MBL
- S (Study design): randomized controlled studies

Search strategy
The prevailing literature overview was based on a literature search in PubMed via MEDLINE, EMBASE and Cochrane library – the Cochrane Central Register of Controlled Trials (CENTRAL) to identify relevant publications to answer the research question. The studies could be written in any language and should be published between January 2000 and February 2017. The last search was on March 3, 2017, by using MeSH (Medical Subject Heading) and [ALL FIELDS] terms. The following search terms and combinations were used: “bone loss” AND “dental implantation”[MeSH Terms] AND “follow up”; OR (“bone resorption”[MeSH Terms] AND “dental implantation”[MeSH Terms] AND “follow up”); OR (“bone loss” AND “dental implants”[MeSH Terms] AND “follow up”); OR (“bone resorption”[MeSH Terms] AND “dental implants”[MeSH Terms] AND “follow up”). The search was limited to the following filters: Humans; Randomised controlled studies.

Inclusion criteria
The following study design criteria were included in the publications search: “randomised controlled study” and “follow-up one year after implantation”. Criteria used to compare the test and control groups: mean age of groups, number of inserted implants, group size, loading protocol (further details see), fixed or removable restoration, implant manufacturer, treatment of implant surface (additive, subtractive, combination of additive and subtractive, combination of different subtractive treatments), survival rate based on implants and mean MBL were further requirements for inclusion.

Exclusion criteria
Exclusions to the trail were: “studies on animals or in vitro”; “reviews”; “case reports” and “clinical trials”; “follow-up one year post-loading”; and “missing data on the above-mentioned groups”.

Data extractions
Two independently working reviewers (JZ and MS) extracted the data from the full text for analysis. Both reviewers double-checked the acquired information. Discrepancies were solved by mutual agreement. While reviewing the publications a chart was created and consecutively updated. The following parameters were extracted and inserted in a chart:
Title
Author
Year of publication
Topic of the publication
Number of implants
Mean age of groups
Number of patients participating
Number of patients subdivided into groups
If fixed or removable restoration
Loading protocol (immediate loading, immediate non-occlusal loading, early loading, conventional loading)
Implant manufacturer
Treatment of implant surface (additive, subtractive, combination of additive and subtractive, combination of different subtractive treatments)
Survival and success rate 1 year after implantation
Mean MBL with SD
Complications of the inserted implants and restorations

Definitions
In the literature, fixed restorations are described as screwed or cemented connection of the abutment to the implant body. Removable prostheses are fixed using a specific retention element to the implant.14

Statistical analysis
In this review, language bias is non-existent, because the identified studies are written exclusively in English. Moreover, the authors tried to minimize the risk of bias by only including randomized controlled studies.

Publication bias might exist because there was no access to unpublished studies.

The overall MBL estimates for fixed and removable restorations were calculated using DerSimonian–Laird models random-effects meta-analysis. The Egger’s test was performed to check for publication bias and the Cochran Q for heterogeneity. The association between 1-year implant survival and MBL was examined using metaregression models. The difference in meta-analytic estimates between removable and fixed restorations was tested with a metaregression including all studies using a dichotomous indicator to distinguish both restoration types. Because of the lack of information on implant success or complications in most of the studies, it was not possible to determine their relationship with MBL. Meta-analysis and metaregression were performed using STATA v.14.0 (StataCorp LP, 2015, College Station, TX, USA).

Results
For creating the review, the authors used the same data referring to the searching of the three databases as shown in a previous review “Marginal bone loss one year after implantation – A systematic review for different loading protocols” (Figure 1).13 22 studies (240 implants for removable restorations and 2,096 implants for fixed restorations) were included in this review.

Description of studies
All listed studies had an observation period of 1 year after implantation using intraoral periapical radiographs (Table 1).13

Alsabeeha et al15 estimated the success rate of the different implant systems on removable restorations. Overdentures connected by Southern Regular Implants (Southern Implants, Irene, South Africa) had the lowest implant success rate of 75% and Neoss Regular (Neoss Ltd., Harrogate, UK) and Southern Wide Implants (Southern Implants, Irene, South Africa) reached 100%. Concerning the different attachment types, overdentures with large ball attachment had the highest success rate of 83.3%, followed by overdentures with locator, 66.7%, and overdentures with standard ball attachment, 63.6%.

The estimated implant success rates for the fixed restorations range between 94.7%33 and 100%.31,33 None of the authors mentioned the prosthesis success rate concerning fixed restorations.

There are also biological and prosthetic complications listed. The most often mentioned complications concerning the biological tissue were severe MBL and periimplant mucositis. Prosthetic complications included abutment screw loosening and fracture of the restoration.

Three randomized controlled clinical studies analyzed the MBL of implants which serve for better retention of overdentures. These results are illustrated in Table 2. All of them conducted examinations in the lower jaw. Alsabeeha et al15 placed one mini implant (Southern Implants (Southern Implants, Irene, South Africa), or Neoss Ltd. (Neoss Ltd., Harrogate, UK)) per patient for supporting the mandibular overdenture, while for the same treatment Maryod et al16 used four mini implants (3M ESPE, Seefeld, Germany). Schincaglia et al17 tested two OsseoSpeed Implants (AstraTech AB, Molndal, Sweden) per patient. Each study dealt with different types of implant surfaces: Alsabeeha et al15 decided to insert implants with a combination of subtractive methods (Southern Implants (Southern Implants, Irene, South Africa) [abraded rough surface of rutile titanium])...
and Neoss Ltd. (Neoss Ltd., Harrogate, UK) [sand-blasted and acid-etched and not a clearly described company-specific treatment]), the subtractive implant surface (blasted) was checked by Maryod et al.\textsuperscript{16} the OsseoSpeed Implants (OsseoSpeed, AstraTech AB, Molndal, Sweden) appearing in the study of Schincaglia et al\textsuperscript{17} were made of a combination of subtractive and additive techniques. Alsabeeha et al\textsuperscript{15} divided the patients into three equal groups: every group received a different type of implant and attachment system, but all the implants were connected to the overdenture also using the early loading protocol. Southern 8-mm-wide Implant and large ball attachments showed the best results with a measurement of MBL 0.13 mm. Neoss Regular Implants (Neoss Ltd., Harrogate, UK) and locator attachments had an MBL of 0.23 mm. The group with the Southern Regular Implants and standard ball attachments had the lowest survival rate of 90.9\%, but an MBL of only 0.2 mm. The other two studies compared the immediate and early loading protocol. The groups with the immediate-loaded implants had a lower survival rate ranging between 91.7\% and 93\%. The MBL of overdentures loaded immediately by Maryod et al\textsuperscript{16} showed a higher MBL compared to the early loaded in this study, 1.03 mm±0.61 mm versus 0.93 mm±0.52 mm. In comparison, in the study of Schincaglia et al\textsuperscript{17} the results were even better, 0.25 mm±0.5 mm versus 0.54 mm±0.5 mm. Figure 2 shows the Forest plot on the MBL around implants supporting removable restorations a year after implantation. The
| Year | First author | Control/test group | Number of implants | Mean age in years (range) | Number of patients in groups | Fixed/removable | Loading protocol | Implant type | Implant surface | Success rate implants | Success rate prostheses | Reported complications |
|------|--------------|-------------------|-------------------|--------------------------|-----------------------------|----------------|-----------------|--------------|----------------|-----------------------|------------------------|------------------------|
| 2011 | Alsabeeha NH 15 | Neoss Regular Implants and locator attachment | 12 | 70 (NR) | 12 | Removable | Early loaded (>2 days to <3 months) | Neoss Regular (Neoss Ltd., Harrogate, UK) | Combination of subtractive methods | 100% | Overdenture with locator: 66.7% | NR |
| 2011 | Alsabeeha NH 15 | Southern Regular Implants and standard ball attachment | 12 | 64 (NR) | 12 | Removable | Early loaded (>2 days to <3 months) | Southern Regular (Southern Implants, Irene, South Africa) | Combination of subtractive methods | 75% | Overdenture with standard ball attachment: 63.6% | NR |
| 2011 | Alsabeeha NH 15 | Southern 8-mm-wide Implants and large ball attachment | 12 | 69 (NR) | 12 | Removable | Early loaded (>2 days to <3 months) | Southern wide (Southern Implants, Irene, South Africa) | Combination of subtractive methods | 100% | Overdenture with large ball attachment: 83.3% | NR |
| 2008 | Cannizzaro G 10 | Flapless placed implants immediately loaded with full-arch prostheses | 90 | 62 (NR) | 15 | Fixed | Immediately loaded (<48 hrs) | SwissPlus Tapered (Zimmer Dental, Carlsbad, USA) | Subtractive method | 98.88% | NR | Soft-tissue ulcers induced by provisional, fracture or loosening of the provisional, fracture of the ceramic of final prosthesis, temporomandibular joint/occlusal/mastication problems, peri-implant tissue complications (total: 8) |

(Continued)
| Year | First author | Control/test group | Number of implants | Mean age in years (range) | Number of patients in groups | Fixed/removable | Loading protocol | Implant type | Implant surface | Success rate implants | Success rate prostheses | Reported complications |
|------|--------------|-------------------|--------------------|--------------------------|-----------------------------|----------------|----------------|--------------|---------------|---------------------|-----------------------|------------------------|
| 2008 | Cannizzaro G16 | Flapless placed implants early loaded at 2 months with full-arch prostheses | 87 | 56 (NR) | 15 | Fixed | Early loaded (>2 days to <3 months) | SwissPlus Tapered (Zimmer Dental, Carlsbad, USA) | Subtractive method | 96.66% | NR | Fracture or loosening of the provisional, temporo-mandibular joint/occlusal/mastication problems, peri-implant tissue complications, esthetic problems (total: 5) |
| 2013 | Cannizzaro G17 | 2 implants placed flapless in fully edentulous mandibles and immediately restored with metal-resin screw-retained cross-arch prostheses | 60 | 63 (37–83) | 30 | Fixed | Immediately loaded (<48 hrs) | Tapered NT Full Osseotite (Biomet 3i, Palm Beach Gardens, USA); ExFeel (MegaGen Implant Co. Limited, Gyeongbuk, South Korea) | Subtractive and additive method/subtractive method | NR | NR | Metal framework not fitting, occlusion to be adjusted, abutment screw loosening, resin tooth detachment/fracture, distal extension framework fracture, patient unsatisfied (total: 16) |
| 2013 | Cannizzaro G17 | 4 implants placed flapless in fully edentulous mandibles and immediately restored with metal-resin screw-retained cross-arch prostheses | 120 | 56 (39–71) | 30 | Fixed | Immediately loaded (<48 hrs) | Tapered NT Full Osseotite (Biomet 3i, Palm Beach Gardens, USA); ExFeel (MegaGen Implant Co. Limited, Gyeongbuk, South Korea) | Subtractive and additive method/subtractive method | NR | NR | |

(Continued)
| Year | First author | Control/test group | Number of implants | Mean age in years (range) | Number of patients in groups | Fixed/removable | Loading protocol | Implant type | Implant surface | Success rate implants | Success rate prostheses | Reported complications |
|------|--------------|-------------------|-------------------|--------------------------|-----------------------------|----------------|-----------------|--------------|----------------|----------------------|----------------------|-------------------------|
| 2015 | Cannizzaro G | Prostheses supported by super-short (5 mm) implants: maxilla | 90 | 58.9 (44–78) | 15 | Fixed | Immediately loaded (<48 hrs) | NanoTite (Biomet 3i, Palm Beach Gardens, USA) | Subtractive and additive method | NR | NR | Prosthesis screw loosening, hypoplastic soft tissue with ulcers, fracture of long distal cantilever, detachment of central incisors |
| 2015 | Cannizzaro G | Prostheses supported by super-short (5 mm) implants: mandible | 60 | 62.9 (47–80) | 15 | Fixed | Immediately loaded (<48 hrs) | NanoTite (Biomet 3i, Palm Beach Gardens, USA) | Subtractive and additive method | NR | NR | |
| 2015 | Cannizzaro G | Prostheses supported by long (11.5 mm) implants: maxilla | 90 | 58.5 (43–72) | 15 | Fixed | Immediately loaded (<48 hrs) | Tapered NT NanoTite (Biomet 3i, Palm Beach Gardens, USA) | Subtractive and additive method | NR | NR | |
| 2015 | Cannizzaro G | Prostheses supported by long (11.5 mm) implants: mandible | 60 | 58.8 (38–72) | 15 | Fixed | Immediately loaded (<48 hrs) | Tapered NT NanoTite (Biomet 3i, Palm Beach Gardens, USA) | Subtractive and additive method | NR | NR | |
| 2015 | Cooper LF | Conical implant-abutment interface | 53 | 43 (18–70) | 48 | Fixed | Immediately nonocclusally loaded | OsseoSpeed (Astra Tech AB, Molndal, Sweden) | Subtractive and additive method | NR | NR | NR |

(Continued)
| Year | First author | Control/test group | Number of implants | Mean age in years (range) | Number of patients in groups | Fixed/removable | Loading protocol | Implant type | Implant surface | Success rate implants | Success rate prostheses | Reported complications |
|------|--------------|-------------------|--------------------|--------------------------|-----------------------------|----------------|-----------------|-------------|----------------|---------------------|------------------------|------------------------|
| 2015 | Cooper LF    | Flat to flat implant–abutment-interface | 53                | 46 (19–78)               | 49                          | Fixed          | Immediately nonocclusally loaded | Nobel Speedy Replace (Nobel Biocare AB, Goteborg, Sweden) | Subtractive and additive method | NR                      | NR                      | NR                     |
| 2015 | Cooper LF    | Platform-switched implant–abutment interface | 50                | 46 (18–81)               | 44                          | Fixed          | Immediately nonocclusally loaded | NanoTite Certain Prevail (Biomet 3i, Palm Beach Gardens, USA) | Subtractive and additive method | NR                      | NR                      | NR                     |
| 2010 | Cooper LF    | Single implants placed in fresh extraction sockets | 58                | 45.1 (NR)                | 55                          | Fixed          | Immediately nonocclusally loaded | OsseoSpeed (Astra Tech AB, Molndal, Sweden) | Subtractive and additive method | NR                      | NR                      | NR                     |
| 2010 | Cooper LF    | Single implants placed in healed ridges | 65                | 42.1 (NR)                | 58                          | Fixed          | Immediately nonocclusally loaded | OsseoSpeed (Astra Tech AB, Molndal, Sweden) | Subtractive and additive method | NR                      | NR                      | NR                     |
| 2015 | Esposito M   | Implant surface roughened with sandblasting and double etching | 137               | 63.6 (47–80)             | 25                          | Fixed          | Immediately loaded (<48 hrs) | iRES iPerio (iRES SAGL, Lugano, Switzerland) | Combination of subtractive methods | NR                      | NR                      | None                   |
| 2015 | Esposito M   | Machined, turned implant surface | 163               | 60.84 (38–81)            | 25                          | Fixed          | Immediately loaded (<48 hrs) | iRES iPerio (iRES SAGL, Lugano, Switzerland) | Machined surface                  | NR                      | NR                      | None                   |

(Continued)
Table 1 (Continued).

| Year | First author | Control/test group | Number of implants | Mean age in years (range) | Number of patients in groups | Fixed/removable | Loading protocol | Implant type | Implant surface | Success rate implants | Success rate prostheses | Reported complications |
|------|--------------|-------------------|--------------------|--------------------------|-----------------------------|----------------|----------------|----------------|----------------|-----------------------|------------------------|------------------------|
| 2012 | Grandi T³⁵   | Implants immediately loaded and restored using definitive abutments | 28 | 53.2 (43–64) | 14 | Fixed | Immediately nonocclusally loaded | JDEvolution (JDental Care S.r.l., Modena, Italy) | Subtractive method | NR | NR | NR |
| 2012 | Grandi T³⁵   | Implants immediately loaded and restored using provisional abutments later replaced by custom-made abutments | 28 | 50.3 (39–60) | 14 | Fixed | Immediately nonocclusally loaded | JDEvolution (JDental Care S.r.l., Modena, Italy) | Subtractive method | NR | NR | NR |
| 2012 | Grandi T³⁶   | Immediately nonocclusally loaded implants | 81 | 51.8 (39–65) | 40 | Fixed | Immediately nonocclusally loaded | JDEvolution (JDental Care S.r.l., Modena, Italy) | Subtractive method | NR | NR | None |
| 2012 | Grandi T³⁶   | Early-loaded implants | 80 | 55.3 (43–65) | 40 | Fixed | Early loaded (>2 days to <3 months) | JDEvolution (JDental Care S.r.l., Modena, Italy) | Subtractive method | NR | NR | None |
| 2014 | Grandi T³⁸   | Immediately loaded single implants using a definitive abutment | 12 | 56 (39–70) | 12 | Fixed | Immediately nonocclusally loaded | JDEvolution (JDental Care S.r.l., Modena, Italy) | Subtractive method | NR | NR | Periimplant mucositis, abutment screw loosening (total: 2) |
| 2014 | Grandi T³⁸   | Immediately loaded single implants using a provisional abutment | 13 | 57.08 (43–74) | 13 | Fixed | Immediately nonocclusally loaded | JDEvolution (JDental Care S.r.l., Modena, Italy) | Subtractive method | NR | NR |

(Continued)
| Year | First author | Number of implants | Number of patients in groups | Mean age in years (range) | Fixed/removable | Loading protocol | Implant type | Implant surface | Implant type | Implant surface | Success rate implants | Success rate prostheses | Reported complications |
|------|-------------|-------------------|----------------------------|--------------------------|------------------|-----------------|--------------|----------------|--------------|----------------|----------------------|----------------------|------------------------|
| 2005 | Horwitz Jp  | 28                | 15                         | 57.27 (NR)               | Fixed            | Conventionally loaded (>3 months) | Chlorhexidine mouthwash | TG (Biomet3i, Palm Beach Gardens, USA) | Subtractive method | Osseotite TG (Biomet3i, Palm Beach Gardens, USA) | NR                   | NR                   | NR                     |
| 2005 | Horwitz Jp  | 33                | 18                         | 51.83 (NR)               | Fixed            | Conventionally loaded (>3 months) | Amine fluoride/stannous fluoride mouthwash | TG (Biomet3i, Palm Beach Gardens, USA) | Subtractive method | Osseotite HA (Osstem Implant Co., Seoul, Korea) | NR                   | NR                   | NR                     |
| 2013 | Kim YKp     | 52                | 26                         | 51.6 (NR)                | Fixed            | Immediately loaded (<48 hrs)     | Osteon TSII HA implants immediately loaded | TG (Biomet3i, Palm Beach Gardens, USA) | Subtractive method | Osteon TSII HA (Oststem Implant Co., Seoul, Korea) | NR                   | NR                   | NR                     |
| 2013 | Kim YKp     | 48                | 24                         | 49.6 (NR)                | Fixed            | Immediately loaded (<48 hrs)     | Zimmer TSV implants immediately loaded | TSV (Zimmer Dental, Carlsbad, USA) | Subtractive method | MDI (3M ESPE, Seefeld, Germany) | NR                   | NR                   | NR                     |
| 2014 | Maryod WH   | 72                | 18                         | 63.4 (NR)                | Removable        | Immediately loaded (<48 hrs)     | Early-loaded mini-implant supporting mandibular overdentures | MDI (3M ESPE, Seefeld, Germany) | Subtractive method | Early-loaded mini-implants supporting mandibular overdentures | NR                   | NR                   | NR                     |
| 2014 | Maryod WH   | 72                | 18                         | 64.8 (NR)                | Removable        | Early loaded mini-implants supporting mandibular overdentures | MDI (3M ESPE, Seefeld, Germany) | Subtractive method | Early-loaded mini-implants supporting mandibular overdentures | NR                   | NR                   | NR                     |
| Year | First author | Number of implants | Control/test group | Implant type | Implant surface | Loading protocol | Success rate implants | Success rate prostheses | Reported complications |
|------|--------------|--------------------|------------------|--------------|----------------|------------------|-----------------------|-----------------------|------------------------|
| 2014 | Meloni SM17 | 18 (28–70)        | Platform-switching implants: split-mouth | Nobel Replace tapered Groovy (Nobel Biocare AB, Goteborg, Sweden) | Subtractive and additive method | Conventionally loaded (>3 months) | Fixed | Conventionally loaded (>3 months) | None | Periimplant mucosal inflammation (total: 1) |
| 2014 | Meloni SM17 | 18 (28–70)        | Regular platform implants: split-mouth | Nobel Replace tapered Groovy (Nobel Biocare AB, Goteborg, Sweden) | Subtractive and additive method | Conventionally loaded (>3 months) | Fixed | Conventionally loaded (>3 months) | None | None |
| 2015 | Meloni SM18 | 15 (NR)           | Socket sealing with epithelial connective tissue graft | Nobel Replace tapered Groovy (Nobel Biocare AB, Goteborg, Sweden) | Subtractive and additive method | Conventionally loaded (>3 months) | Fixed | Conventionally loaded (>3 months) | None | None |
| 2015 | Meloni SM18 | 15 (NR)           | Socket sealing with porcine collagen matrix | Nobel Replace tapered Groovy (Nobel Biocare AB, Goteborg, Sweden) | Subtractive and additive method | Conventionally loaded (>3 months) | Fixed | Conventionally loaded (>3 months) | None | None |
| Year | First author | Control/test group | Number of implants | Mean age in years (range) | Number of patients in groups | Fixed/removable | Loading protocol | Implant type | Implant surface | Success rate implants | Success rate prostheses | Reported complications |
|------|--------------|--------------------|--------------------|--------------------------|-----------------------------|----------------|----------------|----------------|----------------|----------------------|-----------------------|----------------------|
| 2015 | Merli M⁴⁰    | Bone mineral of bovine origin (Bio-Oss, Geistlich Biomaterials AG, Wolhusen, Switzerland) and collagen porcine membranes (Bio-Gide, Geistlich Biomaterials AG, Wolhusen, Switzerland) | 32                  | 56 (31–76)              | 25                           | Fixed         | Conventionally loaded (>3 months) | Element RC Inicell Implants (Thommen Medical AG, Grenchen, Switzerland) | Combination of subtractive methods | NR                | NR                  | Dehiscence of the mucosa, presence of purulent exudate, tingling sensation and hyposensitivity (for both groups) |
| 2015 | Merli M⁴⁰    | Synthetic resorbable bone graft substitute (Ceros TCP, Thommen Medical AG, Grenchen, Switzerland) and porcine pericardium collagen membranes (Jason, Bottis AG, Bettlach, Switzerland) | 29                  | 53.4 (30–76)            | 25                           | Fixed         | Conventionally loaded (>3 months) | Element RC Inicell Implants (Thommen Medical AG, Grenchen, Switzerland) | Combination of subtractive methods | NR                | NR                  | None |
| 2001 | Paolantonio M¹⁹ | Implant placed in a fresh extraction socket: maxilla, split mouth | 24                  | 41 (24–66)              | 48                           | Fixed         | Immediately nonocclusally loaded | Titanium plasma-sprayed solid screwed implants (PHI, Legnano, Italy) | Additive method | NR                | NR                  | None |

(Continued)
| Year | First author | Control/test group | Number of implants | Number of patients in groups | Mean age in years (range) | Loading protocol | Implant type | Implant surface | Success rate implants | Success rate prostheses | Reported complications | (Continued) |
|------|--------------|-------------------|--------------------|-----------------------------|---------------------------|------------------|--------------|----------------|---------------------|-----------------------|------------------------|--------------|
| 2001 | Paolantonio  | M\(^{+}\)          | 24                 | 4 (24-66)                   | Fixed                     | Immediately nonocclusally loaded | Titanium plasma-sprayed solid screwed implants (PHI, Legnano, Italy) | Additive method | NR                   | NR                   | None                   |              |
| 2001 | Paolantonio  | M\(^{+}\)          | 24                 | 4 (24-66)                   | Fixed                     | Immediately nonocclusally loaded | Titanium plasma-sprayed solid screwed implants (PHI, Legnano, Italy) | Additive method | NR                   | NR                   | None                   |              |
| 2001 | Paolantonio  | M\(^{+}\)          | 24                 | 4 (24-66)                   | Fixed                     | Immediately nonocclusally loaded | Titanium plasma-sprayed solid screwed implants (PHI, Legnano, Italy) | Additive method | NR                   | NR                   | None                   |              |

(Continued)
| Year | First author | Number of implants | Mean age in years (range) | Fixed/removable loading protocol | Implant type | Implant surface | Loading protocol | Success rate implants | Success rate prostheses | Reported complications |
|------|--------------|--------------------|--------------------------|---------------------------------|-------------|---------------|-----------------|---------------------|----------------------|------------------------|
| 2010 | Park JC      | 36                 | NR                       | Fixed                            | Osstem SSII Dental Implants (Osstem Implant Co., Seoul, Korea) | Subtractive method | Conventionally loaded (>3 months) | 100%                | NR                  | Severe marginal bone loss due to inflammation (total: 2) |
| 2010 | Park JC      | 39                 | NR                       | Fixed                            | Standard Straumann Dental Implant System (Straumann AG, Basel, Switzerland) | Combination of subtractive methods | Conventionally loaded (>3 months) | 100%                | NR                  | NR                     |
| 2011 | Pieri F      | 20                 | 45.8 (26–67)             | Fixed                            | Samo Smiler System (Samo Biomedica SpA, Cadriano, Italy) | Additive method | Immediately nonocclusally loaded | 94.7%               | NR                  | Abscess associated with a fistula, abutment screw loosening, fracture of the provisional crown (2 prosthetic, 1 biological) |
| 2011 | Pieri F      | 20                 | 46.6 (32–65)             | Fixed                            | Samo Smiler System (Samo Biomedica SpA, Cadriano, Italy) | Additive method | Immediately nonocclusally loaded | 100%                | NR                  | NR                     |

Table 1 (Continued)
Table 1 (Continued).

| Year | First author | Control/test group | Number of implants | Mean age in years (range) | Number of patients in groups | Fixed/removable | Loading protocol | Implant type | Implant surface | Success rate implants | Success rate prostheses | Reported complications |
|------|--------------|-------------------|--------------------|---------------------------|-----------------------------|----------------|----------------|--------------|-------------------|-----------------------|------------------------|------------------------|
| 2016 | Schincaglia GP17 | Immediately loaded implants supporting a locator-retained mandibular overdenture | 30 | 66.6 (53–79) | 15 | Removable | Immediately loaded (<48 hrs) | OsseoSpeed (Astra Tech AB, Molndal, Sweden) | Subtractive and additive method | NR | NR | Denture fractures, insert change, abutment loosening, denture adjustment |
| 2016 | Schincaglia GP17 | Delayed loaded implants supporting a locator-retained mandibular overdenture | 30 | 66.2 (57–85) | 15 | Removable | Early loaded (>2 days to <3 months) | OsseoSpeed (Astra Tech AB, Molndal, Sweden) | Subtractive and additive method | NR | NR | (Continued) |
| Year | First author | Control/test group | Number of implants | Mean age in years (range) | Number of patients in groups | Fixed/removable | Loading protocol | Implant type | Implant surface | Success rate implants | Success rate prostheses | Reported complications |
|------|--------------|-------------------|-------------------|--------------------------|-----------------------------|-----------------|-----------------|--------------|-----------------|---------------------|----------------------|------------------------|
| 2011 | Tallarico M | One-stage early-loaded implants | 38 | 46.71 (26–76) | 29 | Fixed | Early loaded (>2 days to <3 months) | TiUnite Branemark System Implants (41 MKIII Groovy or Nobel 48 Speedy Groovy) (Nobel Biocare AB, Goteborg, Sweden) | Subtractive and additive method | NR | NR | Mobility without pain and swelling (total: 2) |
| 2011 | Tallarico M | Two-stage early-loaded implants | 51 | 48.39 (27–65) | 18 | Fixed | Early loaded (>2 days to <3 months) | TiUnite Branemark System Implants (41 MKIII Groovy or Nobel 48 Speedy Groovy) (Nobel Biocare AB, Goteborg, Sweden) | Subtractive and additive method | NR | NR |
| 2012 | Vandeweghe S | Within comparison of platform-switching implants: switch | 15 | 57 (32–75) | 15 | Fixed | Conventionally loaded (>3 months) | Max (Southern Implants, Irene, South Africa) | Combination of subtractive methods | NR | NR | NR |
estimate for the mean MBL was 0.476 mm (95% CI: −0.305 to 1.258), and heterogeneity was not significant ($p=0.714$). The Egger’s test for freedom of publication bias had a $p>0.1$ ($p=0.252$). It was not possible to quantify the association between 1-year implant survival and MBL because only 3 studies were available to perform the metaregressions.

The 19 randomized controlled clinical studies dealing with the fixed restored implants are shown in Table 3. The study of Cooper et al, dealing with the replacement of single teeth by implants in the anterior maxilla, showed the lowest survival rate of 85.7%. Implants inserted in the trial of Paolantonio et al reached the maximum MBL of 1.37 mm. In contrast to this high value, the lowest MBL was found by Kim et al dealing with two consecutive implants restored with splinted crowns. Conspicuously, the study of Cooper et al measured a bone gain of 1.3 mm. The authors did not mention the possible reasons for this deviation.

Figure 3 shows the Forest plot on the MBL around implants supporting fixed restorations a year after implantation. The estimate for the mean MBL was 0.459 mm (95% CI: 0.325–0.593), and heterogeneity was not significant ($p=0.955$). The Egger’s test for freedom of publication bias had a $p>0.1$ ($p=0.302$). A decrease of −0.083% (95% CI: −0.179 to 0.013 $p=0.086$) in 1-year implant survival per an increase of 1 mm in MBL was observed in fixed restorations.

The IQR for the 1-year implant survival reported in the considered studies was 97.0–100.0% with a median of 99.2%.

The overall MBL estimates for the fixed and removable restorations did not statistically differ (0.363 mm; 95% CI: −0.319 to −1.044; $p=0.279$).

**Discussion**

Patients suffering from partial or total edentulism benefit from the rehabilitation of the situation by inserting dental implants. This process shows a high satisfaction. Several prosthetic reconstructions including either fixed or removable approaches are possible.

While composing this systematic review including a meta-analysis, we only searched for randomized controlled clinical trials in which the MBL was measured 1 year after implantation. Furthermore, we wanted to assess if there is a difference concerning the MBL between the two prosthetic processes. The meta-analysis showed an overall estimated MBL for the removable prostheses of 0.476 mm and for the fixed restorations of 0.459 mm. There is very little difference between these two values, which means that both prosthetic procedures lead to <0.5 mm MBL 1 year after implantation. We noticed that the randomized
controlled clinical studies in this review assessed many different issues such as different implant lengths, platform-matching/platform-switching implants, different loading protocols, submerged/nonsubmerged implants, different ball attachments and abutment connections. In conclusion, the selected randomized controlled clinical studies in this review did not directly compare MBL around implants of removable and fixed prostheses.
| Year | First author | Control/test group                                                                 | Number of implants | Implant surface                  | Survival rate after 1 year (%) | Mean bone loss (mm) | SD (mm) |
|------|--------------|-----------------------------------------------------------------------------------|--------------------|----------------------------------|---------------------------|---------------------|---------|
| 2001 | Paolantonio M | Implant placed in a fresh extraction socket: maxilla, split mouth                  | 24                 | Additive method                  | 100                       | 1.37                | 0.5     |
| 2001 | Paolantonio M | Implant placed in a fresh extraction socket: mandible, split mouth                 | 24                 | Additive method                  | 100                       | 1.18                | 0.5     |
| 2001 | Paolantonio M | Implant placed contralateral in a mature bone: maxilla, split mouth               | 24                 | Additive method                  | 100                       | 1.12                | 0.4     |
| 2001 | Paolantonio M | Implant placed contralateral in a mature bone: mandible, split mouth              | 24                 | Additive method                  | 100                       | 1.12                | 0.4     |
| 2005 | Horwitz J     | Chlorhexidine mouthwash                                                             | 33                 | Subtractive method               | 92.9                      | 1.06                | 0.13    |
| 2005 | Horwitz J     | Chlorhexidine/stannous fluoride mouthwash                                          | 33                 | Subtractive method               | 100                       | 1.27                | 0.25    |
| 2008 | Cannizzaro G  | Flapless placed implants immediately loaded with full-arch prostheses             | 90                 | Subtractive method               | 98.9                      | 0.55                | 0.22    |
| 2008 | Cannizzaro G  | Flapless placed implants early loaded at 2 months with full-arch prostheses       | 87                 | Subtractive method               | 96.7                      | 0.62                | 0.25    |
| 2010 | Park JC       | Nonsubmerged dental implants (Osstem SSII Implant system)                         | 36                 | Subtractive method               | 100                       | 0.79                | 0.42    |
| 2010 | Park JC       | Nonsubmerged dental implants (Standard Straumann Dental Implant System)           | 39                 | Combination of subtractive methods | 93.9                      | 1.07                | 0.46    |
| 2010 | Cooper LF     | Single implants placed in fresh extraction sockets                                 | 58                 | Subtractive and additive method  | 94.5                      | −1.30               | 2.52    |
| 2010 | Cooper LF     | Single implants placed in healed ridges                                            | 65                 | Subtractive and additive method  | 98.3                      | −0.4                | 1.43    |
| 2011 | Talarico M    | One-stage early-loaded implants                                                    | 38                 | Subtractive and additive method  | 94.7                      | 0.86                | 0.37    |
| 2011 | Talarico M    | Two-stage early-loaded implants                                                    | 51                 | Subtractive and additive method  | 100                       | 0.77                | 0.28    |
| 2011 | Pieri F       | Conventional abutments with an internal connection and a matching diameter         | 20                 | Additive method                  | 94.7                      | 0.19                | 0.17    |
| 2011 | Pieri F       | Abutments with morse taper connection and a platform switch                       | 20                 | Additive method                  | 100                       | 0.49                | 0.25    |
| 2012 | Grandi T      | Implants immediately loaded and restored using definitive abutments                | 28                 | Subtractive method               | 100                       | 0.09                | 0.03    |
| 2012 | Grandi T      | Implants immediately loaded and restored using provisional abutments later         | 28                 | Subtractive method               | 100                       | 0.44                | 0.03    |
| 2012 | Grandi T      | Immediately nonocclusally loaded implants                                         | 81                 | Subtractive method               | 100                       | 0.42                | 0.01    |
| 2012 | Grandi T      | Early-loaded implants                                                              | 80                 | Subtractive method               | 100                       | 0.47                | 0.01    |
| 2012 | Vandeweghe S  | Within comparison of platform-switching implants: switch                            | 15                 | Combination of subtractive methods | 100                       | 0.66                | 0.47    |
| 2012 | Vandeweghe S  | Within comparison of platform-switching implants: nonswitch                        | 15                 | Combination of subtractive methods | 100                       | 0.94                | 0.42    |
| 2013 | Cannizzaro G  | 2 implants placed flapless in fully edentulous mandibles and immediately restored with metal-resin screw-retained cross-arch prostheses | 60 | Subtractive and additive method/subtractive method | 100 | 0.74 | 0.54 |
| 2013 | Cannizzaro G  | 4 implants placed flapless in fully edentulous mandibles and immediately restored with metal-resin screw-retained cross-arch prostheses | 120 | Subtractive and additive method/subtractive method | 100 | 0.58 | 0.38 |
| 2013 | Kim YK        | Osstem TSIII HA Implants immediately loaded                                      | 52                 | Subtractive method               | 100                       | 0.05                | 0.67    |
| 2013 | Kim YK        | Zimmer TSV Implants immediately loaded                                           | 48                 | Subtractive method               | 100                       | 0.63                | 0.61    |
| 2014 | Grandi T      | Immediately loaded single implants using a definitive abutment                     | 12                 | Subtractive method               | 100                       | 0.11                | 0.06    |

(Continued)
| Year | First author | Control/test group                                                                 | Number of implants | Implant surface | Survival rate after 1 year (%) | Mean bone loss (mm) | SD (mm) |
|------|--------------|-----------------------------------------------------------------------------------|--------------------|----------------|-----------------------------|-------------------|---------|
| 2014 | Grandi T†    | Immediately loaded single implants using a provisional abutment                    | 13                 | Subtractive method | 100                         | 0.58              | 0.11    |
| 2014 | Meloni SM    | Platform-switching implants: split mouth                                           | 18                 | Subtractive and additive method | 100                        | 0.5               | 0.27    |
| 2014 | Meloni SM    | Regular platform implants: split mouth                                             | 18                 | Subtractive and additive method | 100                        | 0.56              | 0.22    |
| 2015 | Cooper LF    | Conical implant-abutment interface                                                | 53                 | Subtractive and additive method | 100                        | 0.22              | 0.28    |
| 2015 | Cooper LF    | Flat to flat implant-abutment interface                                           | 53                 | Subtractive and additive method | 100                        | 0.56              | 0.22    |
| 2015 | Cooper LF    | Platform-switched implant-abutment interface                                      | 50                 | Subtractive and additive method | 86.4                      | 1.32              | 1.01    |
| 2015 | Esposito M   | Implant surface roughened with sandblasting and double etching                    | 137                | Combination of subtractive methods | 100                      | 0.64              | 0.2     |
| 2015 | Esposito M   | Machined, turned implant surface                                                  | 163                | Machined surface | 98.8                        | 0.68              | 0.23    |
| 2015 | Cannizzaro G | Prostheses supported by supershort (5 mm) implants: maxilla                       | 90                 | Subtractive and additive method | 97.8                      | 0.15              | 0.04    |
| 2015 | Cannizzaro G | Prostheses supported by supershort (5 mm) implants: mandible                       | 60                 | Subtractive and additive method | 100                        | 0.08              | 0.03    |
| 2015 | Cannizzaro G | Prostheses supported by long (11.5 mm) implants: maxilla                          | 90                 | Subtractive and additive method | 100                        | 0.62              | 0.12    |
| 2015 | Cannizzaro G | Prostheses supported by long (11.5 mm) implants: mandible                         | 60                 | Subtractive and additive method | 100                        | 0.51              | 0.1     |
| 2015 | Meloni SM    | Socket sealing with epithelial connective tissue graft                            | 15                 | Subtractive and additive method | 100                        | 0.9               | 0.18    |
| 2015 | Meloni SM    | Socket sealing with porcine collagen matrix                                        | 15                 | Subtractive and additive method | 100                        | 0.84              | 0.21    |
| 2015 | Merli M      | Bone mineral of bovine origin (Bio-Oss, Geistlich Bio- materials AG, Wolhusen, Switzerland) and collagen porcine membranes (Bio-Gide, Geistlich Biomaterials AG, Wolhusen, Switzerland) | 32                 | Combination of subtractive methods | 100                      | 0.77              | 0.36    |
| 2015 | Merli M      | Synthetic resorbable bone graft substitute (Ceros TCP, Thommen Medical AG, Grenchen, Switzerland) and porcine pericardium collagen membranes (Jason, Botis AG, Bettlach, Switzerland) | 29                 | Combination of subtractive methods | 100                      | 0.54              | 0.45    |

Note: †Parameter for studies reporting several groups were summarized.
Regarding the studies dealing with the MBL of removable prostheses, two of three trials compared the immediate and early loading. In both controlled clinical trials, the survival rate of the immediate-loading protocol was lower. The MBL of the immediate-loading protocol measured by Schincaglia et al\textsuperscript{17} was statistically significant (\(p\)-value <0.02) lower than the value of the early loading protocol. Comparably, Maryod et al\textsuperscript{16} proved a statistically significant (\(p\)-value <0.011) higher MBL after 6 months of the immediate-loaded implants. But after 6 months, there was no statistically significant difference concerning MBL between the two loading protocols.

**Figure 3** Meta-analysis of the mean marginal bone loss (MBL) 1 year after implantation for fixed restorations.

**Abbreviations:** Mean, mean difference; dl, DerSimonian–Laird random-effects model.
To come to a decision which might be the most advantageous approach for patients in need of implant-supported overdentures, Ma et al.\(^\text{24}\) compared different loading protocols, surfaces and attachment systems for mandibular two-implant overdentures. They came to the conclusion that different attachment systems do not significantly influence the MBL. Furthermore, machined implant surfaces showed statistically significant (\(p\)-value <0.05) more MBL than subtractive methods. For the subtractive methods, they used Southern\(^5\), Straumann (Straumann Group, Basel, Switzerland) and Steri-Oss (Nobel Biocare, Goteborg, Sweden) Implants. In our review, we included one study of Alsabeeha et al\(^\text{15}\) where they inserted Neoss Implants (Neoss Ltd., Harrogate, UK) between Southern Implants (Southern Implants, Irene, South Africa). Both came to similar results concerning MBL of Southern Implants. Ma et al.\(^\text{24}\) lost 0.16 mm and Alsabeeha et al\(^\text{15}\) lost 0.13 mm in one group and 0.2 mm in the other group. MBL was statistically significantly higher (\(p\)-value <0.05) for implants loaded 2 weeks after insertion in comparison to the implants loaded 12 weeks after implantation in the study of Ma et al.\(^\text{24}\) The difference of MBL of implants loaded 6 or 12 weeks after implantation was not statistically significant (\(p\)-value >0.05). Concerning the implant success rate, they had comparable values to Alsabeeha et al.\(^\text{15}\). The measurements stayed constant after 1 year until 10 years after loading.

To evaluate if there is a difference between overdentures supported by one or two implants, Tavakolizadeh et al.\(^\text{25}\) developed a study design on this topic. Twenty unsatisfied patients received either one or two interforaminal implants. After implant surgery, implants were immediately loaded. The outcome of the MBL was 0.6 mm±0.67 mm for one implant group and 0.6 mm±0.51 mm for the other. These results as well as those of Cordioli et al.\(^\text{26}\) correlate with our results.

To compare this review, for the fixed prostheses, we calculated a mean MBL of 0.459 mm considering no subgroups of the fixed prostheses. The review of Firme et al.\(^\text{27}\) describes the MBL around implants supporting single fixed prostheses and multiple-unit screw-retained prostheses. They included 17 clinical trials, 7 were related to single-implant prostheses and 10 to multiple-unit screw-retained prostheses. The mean MBL and the implant success rate for the single-implant prostheses was 0.58 mm and 100%, respectively, and for the multiple-unit screw-retained prostheses the respective values were 0.9 mm and 89.1–98.9%. They showed no statistical difference (\(p\)-value >0.05) between the two types of prostheses. In this case, it has to be considered that it was not clear when the follow-up was done, 1 year after implantation or 1 year after loading. The long-term study of Lai et al.\(^\text{28}\) showed less MBL.

The authors analyzed 231 short dental implants supporting single crowns in 168 patients using a follow-up of 1, 5 and 10 years. The MBL measured 1 year after implantation was 0.55 mm±0.45 mm. This value is comparable to our results. During the time period of 1–5 years and 5–10 years, the MBL slightly increased, with the values being 0.05 mm±0.10 mm and 0.03 mm±0.14 mm, respectively. These results indicate that most bone remodeling occurs 1 year after implantation.

This systematic review and meta-analysis indicate that both the implants with fixed and with removable restorations lead to low respectively comparable MBL. However, there is a lack of clinical trials which compare these two types of restoration to each other. Further information in studies about the implant and prosthesis success rates are needed to make a clear statement. Other factors may influence the marginal bone more than the type of restoration, namely the loading protocol, or the implant surface. There is a need for further clinical trials to find the factors which lead to MBL in fixed and removable restorations supported by implants.

**Disclosure**
The authors report no conflicts of interest in this work.

**References**

1. Stellingsma C, Vissink A, Meijer HJ, Kuiper C, Raghoebar GM. Implantology and the severely resorbed edentulous mandible. *Crit Rev Oral Biol Med*. 2004;15:240–248.

2. Heath MR. The effect of maximum biting force and bone loss upon masticatory function and dietary selection of the elderly. *Int Dent J*. 1982;32:345–356.

3. Van Steenberghe D, Quirynen M, Calberson L, Demanet M. A prospective evaluation of the fate of 697 consecutive intra-oral fixtures modum Branemark in the rehabilitation of edentulism. *J Head Neck Pathol*. 1987;6:53–58.

4. The glossary of prosthodontic terms. *J Prosthodont Dent*. 1999;81:39–110.

5. Emami E, Heydecke G, Rompré PH, de Grandmont P, Feine JS. Impact of implant support for mandibular dentures on satisfaction, oral and general health-related quality of life: a meta-analysis of randomized-controlled trials. *Clin Oral Implants Res*. 2009;20:533–544. doi:10.1111/j.1600-0501.2008.01693.x

6. Carlsson GE, Kronstrom M, de Baati C, et al. A survey of the use of mandibular implant overdentures in 10 countries. *Int J Prosthodont*. 2004;17:211–217.

7. Naert I, Alsaadi G, Quirynen M. Prosthetic aspects and patient satisfaction with two-implant-retained mandibular overdentures: a 10-year randomized clinical study. *Int J Prosthodont*. 2004;17:401–410.

8. Selim K, Ali S, Reda A. Implant supported fixed restorations versus implant supported removable overdentures: a systematic review. *Open Access Maced J Med Sci*. 2016;4:726–732. doi:10.3889/ oamjms.2016.109

9. Strietzel FP, Reichart PA. Oral rehabilitation using camlog screw-cylinder implants with a particle-blasted and acid-etched microstructured surface. Results from a prospective study with special consideration of short implants. *Clin Oral Implants Res*. 2007;18:591–600. doi:10.1111/j.1600-0501.2007.01375.x

10. Mericske-Stern RD, Taylor TD, Belser U. Management of the edentulous patient. *Clin Oral Implants Res*. 2000;11(Suppl 1):108–125.
Clinical, Cosmetic and Investigational Dentistry 2019:11

11. Sadowsky SJ. The implant-supported prosthesis for the edentulous arch: design considerations. J Prostheth Dent. 1997;78:28–33.

12. Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. PLoS Med. 2009;6:e1000100. doi:10.1371/journal.pmed.1000100

13. Sommer M, Zimmermann J, Grize L, Stubiinger S. Marginal bone loss one year after implantation – a systematic review for different loading protocols. Int J Maxillofac Surg. 2019. doi:10.1016/j.ijoms.2019.03.965

14. Strub JR, Kern M, Türp JC, Witkowski S, Heydecke G, Wolfrat S. Curriculum Prothetik Band III. Berlin, Quintessenz Verlag: 2011.

15. Alsabeh NH, Payne AG, De Silva RK, Thomson WM. Mandibular single-implant overdentures: preliminary results of a randomised-control trial on early loading with different implant diameters and attachment systems. Clin Oral Implants Res. 2011;22:330–337. doi:10.1111/j.1600-0501.2010.02004.x

16. Maryod WH, Ali SM, Shawky AF. Immediate versus early loading of mini-implants supporting mandibular overdentures: a preliminary 3-year clinical outcome report. Int J Prosthodont. 2014;27:553–560. doi:10.11607/jip.3845

17. Schincaglia GP, Rubin S, Thacker S, Dhingra A, Trombelli L, Ioannidou E. Marginal bone response around immediate- and delayed-loading implants supporting a locator-retained mandibular overdenture: a randomized controlled study. Int J Maxillofac Implants. 2016;31:448–458. doi:10.11607/jomi.4118

18. Cooper LF, Reside G, Stanford C, et al. A multicenter randomized comparative trial of implants with different abutment interfaces to replace anterior maxillary single teeth. Int J Maxillofac Implants. 2015;30:622–632. doi:10.11607/jomi.3772

19. Paolantonio M, Dolci M, Scarano A, et al. Immediate implantation in fresh extraction sockets. A controlled clinical and histologic study in man. J Periodontol. 2001;72:1560–1571. doi:10.1902/jop.2001.72.11.1560

20. Kim YK, Lee JH, Lee JY, Yi YJ. A randomized controlled clinical trial of two types of tapered implants on immediate loading in the posterior maxilla and mandible. Int J Maxillofac Implants. 2013;28:1602–1611. doi:10.11607/jomi.3180

21. Cooper LF, Raes F, Reside GI, et al. Comparison of radiographic and clinical outcomes following immediate provisionalization of single-tooth dental implants placed in healed alveolar ridges and extraction sockets. Int J Maxillofac Implants. 2010;25:1222–1232.

22. Berglundh T, Persson L, Klinge B. A systematic review of the incidence of biological and technical complications in implant dentistry reported in prospective longitudinal studies of at least 5 years. J Clin Periodontol. 2002;29(Suppl 3):197–212.

23. Gamper FB, Benic GI, Sanz-Martin I, Asgeirsson AG, Hammerle CHF, Thoma DS. Randomized controlled clinical trial comparing one-piece and two-piece dental implants supporting fixed and removable dental prostheses: 4- to 6-year observations. Clin Oral Implants Res. 2017;29:1553–1559. doi:10.1111/cio.13025

24. Ma S, Tawse-Smith A, Thomson WM, Payne AG. Marginal bone loss with mandibular two-implant overdentures using different loading protocols and attachment systems: 10-year outcomes. Int J Prosthodont. 2010;23:321–332.

25. Tavakolizadeh S, Vafaei F, Khoshhal M, Ebrahimbazadeh Z. Comparison of marginal bone loss and patient satisfaction in single and double-implant assisted mandibular overdenture by immediate loading. J Adv Prosthodont. 2015;7:191–198. doi:10.4047/jap.2015.7.3.191

26. Cordioli G, Majzoub Z, Castagna S. Mandibular overdentures anchored to single implants: a five-year prospective study. J Prostheth Dent. 1997;78:159–165.

27. Firme CT, Vettore MV, Melo M, Vidigal GM Jr. Peri-implant bone loss around single and multiple prostheses: systematic review and meta-analysis. Int J Maxillofac Implants. 2014;29:79–87. doi:10.11607/jomi.3316

28. Lai HC, Si MS, Zhuang LF, Shen H, Liu YL, Wisnejejer D. Long-term outcomes of short dental implants supporting single crowns in posterior region: a clinical retrospective study of 5–10 years. Clin Implant Dent Relat Res. 2013;24:230–237. doi:10.1111/j.1600-0501.2012.02452.x

29. Horwitz J, Machtei EE, Zubi O, Peled M. Amine fluoride/stannous fluoride and chlorhexidine mouthwashes as adjuncts to single-stage dental implants: a comparative study. J Periodontol. 2005;76:334–340. doi:10.1902/jop.2005.76.3.334

30. Cannizzaro G, Torchio C, Leone M, Esposito M. Immediate versus early loading of flapless-placed implants supporting maxillary full-arch prostheses: a randomised controlled trial. Eur J Oral Implantol. 2009;8(Suppl 1):127–139.

31. Park JC, Ha SR, Kim SM, Kim MJ, Lee JB, Lee JH. A randomized clinical 1-year trial comparing two types of non-submerged dental implants. Clin Implant Dent Relat Res. 2010;21:228–236. doi:10.1111/j.1600-0501.2009.01828.x

32. Tallarico M, Vaccarella A, Marzi GC. Clinical and radiological outcomes of 1- versus 2-stage implant placement: 1-year results of a randomised clinical trial. Eur J Oral Implantol. 2011;4:13–20.

33. Pieri F, Aldini NN, Marchetti C, Cornalesi G. Influence of implant-abutment interface design on bone and soft tissue levels around immediately placed and restored single-tooth implants: a randomized controlled clinical trial. Int J Maxillofac Implants. 2011;26:169–178.

34. Vandeweghe S, De Bruyn H. A within-implant comparison to evaluate the concept of platform switching: a randomised controlled trial. Eur J Oral Implantol. 2012;5:253–262.

35. Grandi T, Guazzetti P, Samaran R, Garuti G. Immediate positioning of definitive abutments versus repeated abutment replacements in immediately loaded implants: effects on bone healing at the 1-year follow-up of a multicentre randomised controlled trial. Eur J Oral Implantol. 2012;5:9–16.

36. Grandi T, Garuti G, Guazzetti P, Tarabini L, Forabosco A. Survival and success rates of immediately and early loaded implants: 12-month results from a multicentric randomized clinical study. J Oral Implantol. 2012;38:239–249. doi:10.1563/AAOJ-00149

37. Cannizzaro G, Felice P, Scardi E, et al. Immediate loading of 2(all-on-2) versus 4 (all-on-4) implants placed with a flapless technique supporting mandibular cross-arch fixed prostheses: 1-year results from a pilot randomised controlled trial. Eur J Oral Implantol. 2013;6:121–131.

38. Grandi T, Guazzetti P, Samaran R, Maghareh H, Grandi G. One abutment-one time versus a provisional abutment in immediately loaded post-extractive single implants: a 1-year follow-up of a multicentre randomised controlled trial. Eur J Oral Implantol. 2014;7:141–149.

39. Meloni SM, Jovanovic SA, Lolli FM, et al. Platform switching vs regular platform implants: nine-month post-loading results from a randomised controlled trial. Eur J Oral Implantol. 2014;7:257–265.

40. Merli M, Moscatelli M, Mariotti G, Pagliaro U, Raffaelli E, Nieri M. Comparing membranes and bone substitutes in a one-stage procedure for horizontal bone augmentation. A double-blind randomised controlled trial. Eur J Oral Implantol. 2015;8:271–281.

41. Cannizzaro G, Felice P, Buti J, Leone M, Ferri V, Esposito M. Immediate loading of fixed cross-arch prostheses supported by flapless-placed superstructure or long implants: 1-year results from a randomised controlled trial. Eur J Oral Implantol. 2015;8:27–36.

42. Esposito M, Felice P, Barausse C, Pistilli R, Grandi G, Simon M. Immediately loaded machined versus rough surface dental implants in edentulous jaws: one-year postloading results of a pilot randomised controlled trial. Eur J Oral Implantol. 2015;8:387–396.

43. Meloni SM, Tallarico M, Lolli FM, Deledda A, Pisanò M, Jovanovic SA. Postextraction socket preservation using epithelial connective tissue graft vs porcine collagen matrix. 1-year results of a randomised controlled trial. Eur J Oral Implantol. 2015;8:39–48.
