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# Feasibility of Dental Implant Replacement in Failed Sites: A Systematic Review

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**Purpose:** To assess the clinical outcomes of replaced implants after removal of failed ones. In addition, associated risk factors that might affect the final outcome of these procedures were also explored.

**Materials and Methods:** An electronic literature search was conducted by two reviewers in several databases for articles written in English up to November 2014. Human clinical trials with a minimum of 10 subjects enrolled that reported clinical outcomes with a mean follow-up period of at least 12 months after implant replacement were included. Implant survival and nonmodifiable/modifiable factors at second and third implant placement attempts were studied. Hence, the PICO question that was aimed to be addressed was: Do patients undergoing implant replacement (second and third attempts) in previous failed sites have comparable clinical outcomes by means of implant survival/failure rate to implants placed at the first attempt?

**Results:** Five retrospective clinical cohort studies and two case series satisfied the selection criteria and thus were included in this review. In total, 396 patients were studied due to implant replacement in previous failed sites. The survival rate for implant replacement at the second attempt was 88.84% (390/439; range, 71% to 94.6%) with a mean follow-up of 41.59 ± 16.77 months. Thirty-one implants were replaced for a third attempt with a mean survival rate of 74.19% (23/31) at the follow-up of 29.66 ± 14.71 months. Major risk indicators were generally divided into patient-related factors (health status, smoking habits, and oral hygiene maintenance), implant characteristics (dimensions, coating, and loading), and site characteristics (bone quality and density, vertical and horizontal dimensions, soft tissue around the implant). **Conclusion:** Implant replacement is a reasonably feasible option for scenarios of early and late implant failure. However, modifiable risk factors must be controlled before proceeding for implant replacement. *INT J ORAL MAXILLOFAC IMPLANTS* 2016;31:xxx-xxx. doi: 10.11607/jomi.4312

**Keywords:** endosseous implant, evidence-based dentistry, implant replacement, reimplantation, risk factors, survival rate

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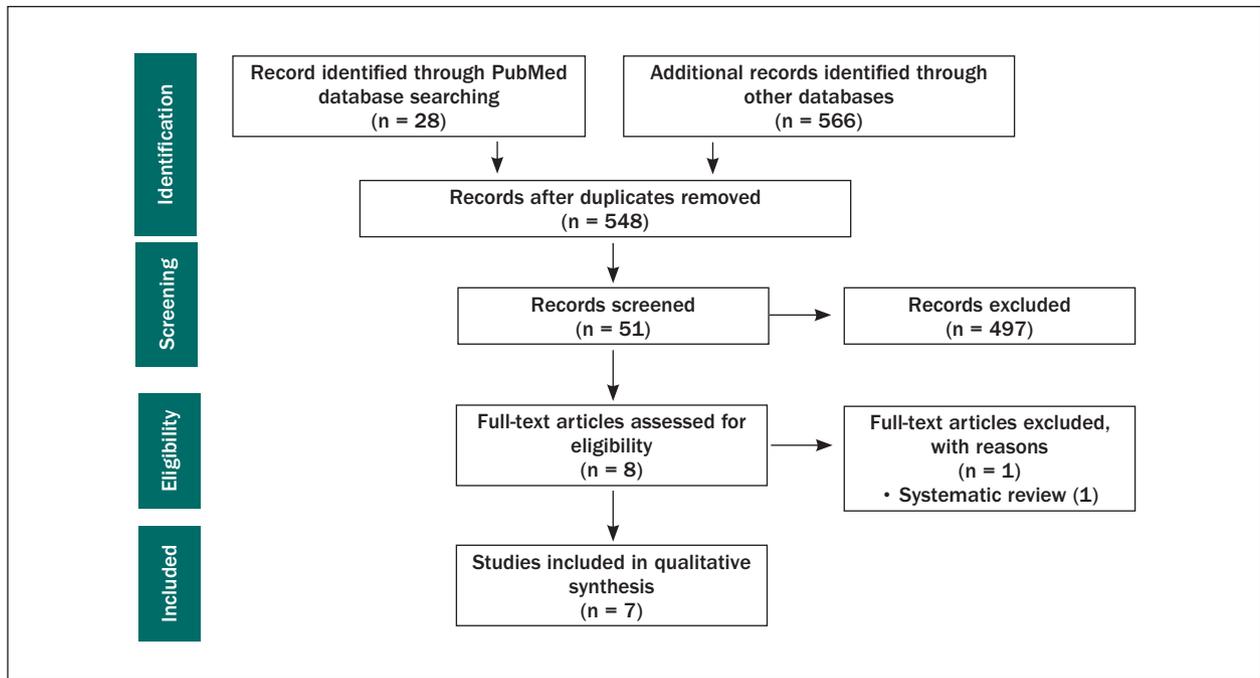
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Currently, implant survival does not represent a challenge anymore due to the advances in the knowledge and the industry of oral implantology. In fact, clinicians are in the pursuit of excellence to not only deliver function, but also esthetics capable of mimicking missing tissues. Nonetheless, the increase in popularity comes with failures due to the lack of enough understanding of related risk factors. For instance, long-term studies have shown a range of 2.7% up to 47.1% of implants affected by peri-implantitis, and those implants will fail if not treated in a reasonable timeframe. These are most likely to occur in the presence/history of periodontitis, smoking, poor plaque control, genetic factors, diabetes, occlusal overload, and residual cement.<sup>1</sup> Therefore, cases that are eligible for implants to rehabilitate missing function/esthetics must be thoroughly evaluated to minimize the risk of failure.

Dental implant failure can be classified as early or delayed failure, occurring before or after placement of the prosthesis, respectively. Osseointegration is a histologic term and clinically can be shown as a direct structural and functional connection between the alloplastic material



**Fig 1** PRISMA flowchart of the screening process in the different databases.

and bone.<sup>2</sup> As such, failure is the movement of the implant owing to failure of osseointegration and radiolucency of the bone in the vicinity of the implant.<sup>3–6</sup> To prevent continuous bone loss, failed implants must be retrieved.<sup>3,7</sup> Factors that may trigger implant failure are diverse, including those related to implant macrodesign/microdesign and composition, biologic issues, anti-infective preventive measures, surgical technique, host-related factors, and iatrogenic factors.<sup>8–14</sup>

Due to the poor bone quality/quantity, failed implant sites present a challenging therapeutic dilemma for clinicians. Nevertheless, in some cases, implant therapy is the only treatment option that will allow a fixed prosthetic reconstruction. Recently, Quaranta et al,<sup>15</sup> in a thorough systematic review, aimed to assess survival and success rates of implant replacement in previously failed sites, reporting a survival rate ranging from 71% to 100%. However, many factors that caused implant failure at second and third attempts were not assessed. Hence, the aim of this study was not only to study the current evidence-based feasibility of implant replacement, but also to give insight on the related risk factors that may cause implant failure, or in other words, to increase the predictability at second and third implant replacement attempts.

## MATERIALS AND METHODS

### Information Sources

An electronic search of the dental literature in several databases, including PubMed-MEDLINE, EMBASE, Cochrane

Central Register of Controlled Trials, and Cochrane Oral Health Group Trials Register databases for articles written in English was undertaken by two reviewers (W.Z. and F.W.) to identify papers published in English up to November 2014.

The reporting of this systematic review followed the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) statement.

The focused PICO question (patient, intervention, comparison, outcome) was as follows:

- P: Complete or partial atrophic or nonatrophic grafted or pristine edentulous subjects
- I: Implant placement at second or third attempt in previously failed site
- C: Second and third implantation attempts
- O: Primary outcome: implant survival and failure rate (%); secondary outcome: identifiable influencing factors

### Screening Process

For the PubMed-MEDLINE screening, combinations of controlled terms (MeSH and Emtree) and keywords were used whenever possible. The search terms used, where “[mh]” represented the MeSH terms and “[tiab]” represented the title and/or abstract, for the PubMed search were: (((“dental implantation, endosseous”[mh] OR “dental implants”[mh])) AND (((replantation [mh]) or (failed implant [tiab]) or (implant replacement [tiab]) AND English [la] NOT (letter [pt] OR comment [pt] OR editorial [pt]) NOT (“animals”[mh])). For other databases, keywords

**Table 1** Descriptive Information about the Included Studies

Study	Study design	No. of implants (1st)	Implant survival rate (1st), %	No. of replaced implants (2nd)	Replaced implant survival rate (2nd), %	No. of rereplaced implants (3rd)	Rereplaced implant survival rate (3rd), %	Follow-up (mo)	Risk of bias
Alsaadi et al <sup>16</sup> (2006)	CS	NR	NR	58	87.9	–	–	9–49	High
Grossmann and Levin <sup>17</sup> (2007)	RC	1,387	93.1	31	71	2	50	19.4 ± 11.4 (6–46)	High
Machtei et al <sup>6</sup> (2008)	RC	NR	NR	79	83.5	–	–	29.9 ± 2 (7–78)	High
Kim et al <sup>20</sup> (2010)	RC	NR	NR	60	88.3	7	100	22.0 ± 14.56	High
Machtei et al <sup>18</sup> (2011)	CS	NR	NR	NR	NR	15	60	NR	High
Mardinger et al <sup>19</sup> (2012)	RC	144	0	144	92.4	7	85.71	48 ± 1.27 (12–180)	High
Wang et al <sup>21</sup> (2015)	RC	10,234	99.02	67	94.6	–	–	69.4 ± 27.0	High

NR = not reported; CS = case series; RS = retrospective cohort study.  
 – = Due to the study design, there were no data for this parameter.

such as 'dental' AND 'implant' AND 'replacement'/'reimplantation'/'replantation' were combined. Additionally, a manual search of implant-related journals, including *Clinical Implant Dentistry and Related Research*, *The International Journal of Oral & Maxillofacial Implants*, *Clinical Oral Implants Research*, *Implant Dentistry*, and *The International Journal of Periodontics & Restorative Dentistry*, from January 2014 up to November 2014, was also performed by one reviewer (W.Z.) to ensure a thorough screening process.

### Eligibility Criteria

The inclusion criteria were:

- Prospective or retrospective cohort or case series involving human subjects specifically designed to investigate dental implants placed in previously failed sites
- ≥ 10 human subjects for a follow up of ≥ 12 months
- Clinical outcomes (ie, survival and failure rates) of implant replacement at first, second, and/or third attempt
- Articles in English language
- Use of root-form or cylindrical titanium implants with machine or modified surfaces

Accordingly, several factors, such as study design, number of patients, number of implants, removal time, survival rate at the second and third time, interval between retrieval and replacement and follow-up, were extracted from the selected studies and qualitatively analyzed.

The exclusion criteria were:

- Human clinical trials and case series reports with fewer than 10 patients
- Preclinical and in vitro studies
- Studies concerning treatment of patients with conditions possibly affecting survival or success rates of implant treatment (ie, nontreated periodontal disease, uncontrolled diabetes, osteoporosis, previous irradiation in the head and neck region).
- Case series and cohort studies that did not provide enough or clear data or studies in different languages from English were excluded.

References in the excluded articles were also screened for studies that fulfilled the inclusion criteria.

### Quality Assessment

The Newcastle-Ottawa scale (NOS) was used to assess the quality of such studies for a proper understanding of nonrandomized studies. This was performed by two investigators (A.M. and B.E.). Cohen's kappa coefficient was used to assess interrater agreement.

### Data Analysis

Agreement between the reviewers was calculated by Cohen's k statistical analysis. The mean follow-up of the selected reports was calculated as the weighted mean on the number of implants investigated at each stage

**Table 2 Characteristics of Patients and the Placed Implants in First Implantation**

	No. of patients	Sex (M/F)	Age (y)	Smoking (Y/N)	Length (mm)	Diameter (mm)	Surface
Alsaadi et al <sup>16</sup>	578	252/326	44 (22–84)	83/495	NR	NR	Machined/ TiUnited
Grossmann and Levin <sup>17</sup>	1,215	1,073/142	33.2 (19.5–53)	NR	12.98 ± 1.05	3.73 ± 0.37	NR
Machtei et al <sup>6</sup>	NR	NR	53.71 ± 1.3 (22–84)	NR	12.1 ± .19 (8–16)	3.9 ± 0.06 (3.25–5)	NR
Kim et al <sup>20</sup>	537	NR	53.2 ± 10.8	NR	NR	NR	NR
Machtei et al <sup>18</sup>	NR	NR	48 ± 14.1	NR	12.2 ± 1.4	3.6 ± 0.3	medium roughness
Mardinger et al <sup>19</sup>	144	60/84	56.5 ± 9 (31–73)	34/110	12.125 (10–16)	4 ± 0.477 (3.25–5)	NR
Wang et al <sup>21</sup>	6,456	NR	42.3 ± 18.2 (21–68)	NR	10.06 ± 1.27 (6–12)	3.85 ± 0.53 (3.3–4.8)	SLA

M = male; F = female; Y = yes; N = no; NR = not reported; GBR = guided bone regeneration; SLA = sand-blasted, large-grit, acid-etched.

– = Due to the study design, there were no data for this parameter.

of the study. Data were presented at the implant level. The statistical analysis was performed using SPSS for Windows (Release 19.0, standard version, SPSS) with a significance level of 5%. No quantitative analysis (meta-analysis) could be performed due to the high heterogeneity of the data. Therefore, only qualitative appraisal of the retrieved information was descriptively analyzed for the systematic review. Only data of interest through the descriptive result section were analyzed to figure out the statistical significance.

## RESULTS

### Study Selection and Data Extraction

The electronic search identified 594 articles. Following analysis of the titles and abstracts, 497 articles were excluded, leaving 97 articles suitable for inclusion based on the titles. After applying the inclusion criteria in reviewing the 51 abstracts, eight of the abstracts were deemed suitable for full-text analysis. Of these, seven articles<sup>6,16–21</sup> were found to be acceptable for inclusion. Therefore, a total of seven articles were qualitatively analyzed (Fig 1). A Cohen's kappa interrater agreement of 1 was reached.

### Study Quality

The criteria for treatment success varied. Implant osseointegration periods, implant characteristics, and follow-ups differed considerably interstudy/intrastudy. The quality of included studies was not comparative in nature. The search failed to reveal any randomized controlled clinical trials (RCTs). The seven eligible publications included five retrospective articles<sup>6,17,19–21</sup> and two case series.<sup>16,18</sup> NOS was conducted to identify the quality of the included studies. Due to the nature of these, a moderate risk of bias was detected (5.71 ± 0.7). A Cohen's kappa interrater examiner of 0.94 was reached.

### Patients Selected

The included studies involved a total of 396 patients with ages ranging from 19.5 to 84 years (mean age: 50.13 ± 7.2 years). Participants' medical status and smoking habits were reported in all the studies. Among the 396 patients, 72 patients were diagnosed with preexisting controlled chronic periodontal disease of different severities before original implant placement, four patients with diabetes mellitus with good glycemic control (one type I and three type II), and two patients with osteoporosis. There were 78 smoking patients and 318 nonsmokers. Of these smoking patients, 11 (14.1%) smoked > 10 cigarettes/

Grafted (Y/N)	Time of failure (mo)	Reason for failure
NR	NR	nonintegration
NR	5.9 ± 4.4	–
NR	8.9 ± 2.1 (1–88)	mobility 69.5%; inflammation and suppuration 23.27%; prolonged acute pain 7.3%
none 10%; GBR 10%; simple bone graft 10%; bone-added osteotome sinus elevation 21.7%; osteotome sinus elevation 5%; sinus lateral 33.3%; ridge split 1.7%; vertical onlay bone graft 1.7%	early failure 68.3% late failure 31.7%	failure of osseointegration 86.7%; inflammation 5%; infection 5%; fixture fracture 1.7%; malposition 1.7%
NR	7.6 ± 14.9 (0.5–60)	biologic failure
none 65(45%); local augmentation 13 (9%); sinus augmentation 23 (16%); immediate implantation 4 (3%); unknown 39 (27%)	early failure 94 (65%) late failure 50 (35%)	lack of osseointegration 37.5%; infection 14.6%; overload 16.6%; unknown 31.3%
none 49; GBR 4; minor autogenous particle bone grafting 2; transalveolar sinus elevation 9; transalveolar sinus elevation +bone grafting 2; lateral window sinus elevation 1	early failure	biologic failure

day, 47 (60.3%) smoked < 10 cigarettes/day, while 20 (25.6%) were unstated. No clear data were stated about the number of patients who had more than one implant replaced.

### Implant Characteristics

Four hundred seventy implants were inserted to replace the previously failed ones, in which 31 implants were placed in sites where previous implants had failed twice. The reported implant length ranged from 8 to 16 mm, and the implant diameter ranged from 3.25 to 5.0 mm. Different implant systems were utilized. Implant surface characteristics were reported in three articles<sup>16,18,21</sup> and again varied between studies.

### Survival and Success Rate of Replaced Implants

The survival rate of the second implantation attempts was reported in all screened studies except for one,<sup>18</sup> ranging from 71% to 94.6%, showing an overall mean survival rate of 88.84% (390/439) within a follow-up period of 41.59 ± 16.77 months (95% CI: 39.90 to 43.28). Four studies<sup>17–20</sup> mentioned the third implantation attempts and showed a large deviation for implants' survival rate, which were 50% (1/2),<sup>17</sup> 60% (9/15),<sup>18</sup> 85.7% (6/7),<sup>19</sup> and 100%(7/7)<sup>20</sup>, respectively. In total, eight out of 31 implants

failed and resulted in an overall mean survival rate of 74.2% within a mean follow-up period of 29.66 ± 14.71 months (95% CI: 24.26 to 35.06; Table 1).

When applicable, success and survival rates found in the articles were defined according to the criteria described by Albrektsson et al.<sup>22</sup> Only two studies included in this review reported the cumulative success rate, which was 71%<sup>17</sup> and 90.6%,<sup>21</sup> respectively.

### Early Loss of Initial Implantation

When analyzing the failure time of initial implantation in pristine sites, most of the implant failures reported were early failures<sup>6,17–21</sup>; late failure was only reported by Mardinger et al<sup>19</sup> and Kim et al<sup>20</sup> (35% and 31.7%, respectively). Most of the first implantation failure was due to biologic reasons (ie, peri-implantitis), manifesting mobility, failure of osseointegration, inflammation and suppuration, infection, prolonged acute pain, and overload. Few mentioned nonbiologic failure (technical failures), such as implant fracture and/or prosthetic failure. According to Kim et al,<sup>20</sup> only 1.7% of their failure was due to implant fracture (Table 2).

### Timing of Reimplantation

There were five studies<sup>16–18,20,21</sup> that provided comparative data on the time interval between failed implant retrieval

**Table 3 Characteristics of Patients and the Placed Implants in Second Implantation**

Study	No. of patients	Sex (M/F)	Interval between removal/reimplantation (mo)	Health status	Smoking (Y/N)	Location (max/mand)
Alsaadi et al <sup>16</sup>	41	23/18	4–6	Osteoporosis: 2	12/29	38/20
Grossmann and Levin <sup>17</sup>	28	25/3	5.8 ± 5.2 (0–26)	non-insulin-dependent diabetes mellitus: 1; controlled chronic periodontal disease: 16	3/25	16/15
Machtei et al <sup>18</sup>	56	NR	6.75 ± 1.12 (0–49)	controlled chronic periodontal disease: 56; type II diabetes with good glycemic control: 3	15/41	42/37
Kim et al <sup>20</sup>	49	35/14	immediate 48.3% delay 51.7% 2.40 ± 3.06	all healthy	0/49	46/14
Machtei et al <sup>18</sup>	NR	NR	10.0 ± 9.2 (0–30)	all healthy	NR	NR
Mardinger et al <sup>19</sup>	144	60/84	4.8 ± 5.45 (1–36)	ASA1: 129; ASA2: 15	34/110	73/71
Wang et al <sup>21</sup>	66	38/28	6.3 ± 3.1 (3–14)	diabetes mellitus: 3	12/54	30/37

M = male; F = female; max = maxilla; mand = mandible; Y = yes; N = no; NR = not reported; GBR = guided bone regeneration; SLA = sand-blasted, large-grit, acid-etched.  
 – = Due to the study design, there were no data for this parameter.

**Table 4 Characteristics of Patients and the Placed Implants in Third Implantation**

Study	3rd implantation				
	No. of patients	Length (mm)	Diameter (mm)	Time of failure (mo)	Follow-up (mo)
Grossmann and Levin <sup>17</sup>	2	NR	NR	NR	10
Kim et al <sup>20</sup>	NR	NR	NR	–	22.0 ± 14.56
Machtei et al <sup>18</sup> (2011)	12	3.80 ± 0.3	12.4 ± 1.6	5.8 ± 2.6; 1–8	44.1 ± 35; 4–48
Mardinger et al <sup>19</sup>	7	11.5; 8–13	3.95 ± 0.46; 3.75–4.7	NR	12

NR = not reported.  
 – = Due to the study design, there were no data for this parameter.

and the placement of implants at the second attempt. The time interval was expressed in months and ranged from 0 to 49 months. Among 33 implants replaced immediately after failed implant retrieval, three implants failed, corresponding to a 9.1% failure rate. Twenty-six out of 197 implants replaced in the delayed implantation group failed, corresponding to a failure rate of 13.2%. No significant differences were observed between the immediate

and delayed groups ( $P = .433$ ). Statistical results in failure time of replaced implants were clearly expounded in three studies.<sup>16–18</sup> There is evidence to show that most of the reimplantation failures were concentrated during the healing period or early loading phase and behaved as an early failure. The average time to replacement implant failure was  $6.55 \pm 5.53$  months after implant insertion (range = 0.5 to 24 months; median = 5.25 months).

Position (anterior/posterior)	Length (mm)	Diameter (mm)	Surface	Grafted (Y/N)	Time of failure (mo)	Reason for failure
24/34	NR	NR	machined surface: 29; TiUnited surface: 29	NR	11.43 ± 6.73 (3–24)	NR
11/20	13.18 ± 1.38	3.66 ± 0.47	NR	1/30	3.2 ± 2.3	NR
21/58	11.99 ± 0.17 (10–15)	3.99 ± 0.07 (3.25–5)	NR	lateral augmentation: 26; sinus augmentation: 6	NR	NR
5/55	NR	NR	NR	none 28.3%; GBR 51.7% bone-added osteotome sinus elevation 28.3%; additional implant placement 21.7%; bone graft 70%	NR	NR
NR	12.6 ± 1.5	3.7 ± 0.3	medium roughness	NR	7.4 ± 9.5 (1–39)	biologic failure
29/115	11.86 (8–16)	3.9 ± 0.49 (3.25–5)	NR	none 78 (54%); GBR 56 (39%); bone augmentation before replacement: 10 (7%)	early failure: 2 late failure: 9	lack of osseointegration 19%; infection 0%; overload 9%; unknown 72%
25/42	10.18 ± 1.34 (6–12)	3.78 ± 0.50 (3.3–4.8)	SLA	None 43; GBR 9; Minor autogenous particle bone grafting 4; Transalveolar sinus elevation 7; Transalveolar sinus elevation + bone grafting 4; Lateral window sinus elevation 0	early failure: 1; late failure: 1	uncontrolled infection and progressive bone loss

### Additional Bone Grafting for Further Implantation Attempts

Four articles<sup>6,19–21</sup> reported a total of 159 out of 350 sites/implants with inadequate bone volume. Accordingly, these underwent additional bone augmentation procedures during the secondary implantation. The mean rate of bone augmentation was 45.43% (159/350). Three studies<sup>19–21</sup> stated specific surgical techniques in which most implants (81.56%) underwent guided bone regeneration (GBR) with or without membrane, followed by transalveolar sinus elevation (9.22%), lateral window sinus elevation (8.51%), transalveolar sinus elevation + bone grafting (7.80%), and minor autogenous particle bone grafting (2.84%). Only Machtei et al<sup>6</sup> reported the incidence of replaced implant failure in previously grafted sites (3/18 = 16.67%). However, both Machtei et al<sup>6</sup> and Kim et al<sup>20</sup> indicated that after site augmentation, implant survival was not associated with greater failure compared with implants that were placed in pristine bone [Tables 3 and 4].

### Related Factors to Failure at Implant Replacement

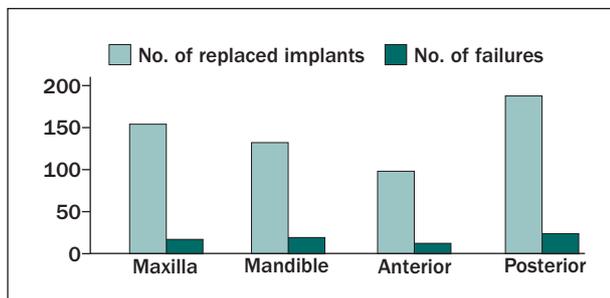
**Anatomical Location.** Figure 2 summarizes the data extracted from five studies<sup>6,16–19,21</sup> reporting on the distribution of implant replacement location. The failure rate in the maxilla and mandible (13.24% and 16.67%, respectively) did not differ statistically ( $P = .447$ ). Likewise, there was no difference in the failure rate between sites (anterior: 15.29%; posterior: 14.55%;  $P = .96$ ).

### Type of Restoration.

Four articles<sup>17,19–21</sup> reported the type of restoration of the replaced implants. The most common type of prosthesis associated with failure was single crown, followed by fixed partial dentures.

### Peri-implant Marginal Bone Loss and Related Factors.

Two studies<sup>20,21</sup> evaluated the condition of the tissue surrounding the replaced implants at the final follow-up. Marginal bone loss ( $0.33 \pm 0.49$  mm;  $1.7 \pm 1.3$  mm)



**Fig 2** Distribution of replaced implant location and incidence of failures.

and Plaque Index ( $0.81 \pm 1.05$  mm; 0.3 mm for the first year and 0.45 mm for the second year) were assessed in both studies. Different soft tissue parameters were selected, including pocket depth, gingival index, and keratinized mucosa thickness. According to Wang et al,<sup>21</sup> the mean modified sulcus Bleeding Index (mSBI) was 0.6 at the first-year follow-up, and 12 implants showed positive mSBI at the last follow-up.

**Other Risk Factors.** Other risk factors such as a lack of peri-implant keratinized tissue, residual dental cement, or occlusal trauma were not clearly expounded in the articles included; therefore, no clear conclusion can be drawn.

## DISCUSSION

It is traditionally held that implant replacement at the same site should be performed after bone healing.<sup>23,24</sup> Adell et al<sup>24</sup> suggested that an implant replacement should be carried out 9 to 12 months after the removal of the failed/failing one. However, recent studies showed no significant difference in the failure rate of the second reimplantation attempt between immediate and delayed replacement groups. Several studies reported immediate implant replacement with a wider diameter in the same socket,<sup>25,26</sup> and suggested that a 1-year healing period might not be necessary.

Immediate replacement has several advantages. As it has been noted in the case of tooth extraction,<sup>27,28</sup> the alveolar bone volume after the removal of a hopeless tooth could undergo a continuous remodeling process, particularly in early phases (up to 50% of the original width in the first 3 months).<sup>29</sup> Hence, immediate reimplantation can minimize future bone resorption. Furthermore, the immediate implantation in these cases represents an immediate solution to a clinical complication and noticeably reduces the length of treatment and the number of surgical procedures.<sup>25</sup> However, there is still a lack of literature showing the three-dimensional changes for immediate vs delayed implant replacement.

Despite all this, when performing the immediate implant replacement, indications must be selected strictly. When substantial infection is associated with an explanted implant, the clinician may have to evaluate the type of infection. Recently, Chrcanovic et al<sup>30</sup> suggested that a chronic infection is not a reason for postponing the surgery, with preventive measures. For instance, the application of 0.12% chlorhexidine was associated with a reduced rate of complications compared with no other chemotherapeutic agent (4.1% vs 8.7%). Nonetheless, if there is an active infection, the clinician may have to postpone implant replacement to permit the resolution of the infection.

Several factors influence the prognosis of implant replacement and can contribute to the failure. The major reported predictors for implant success are generally divided into three aspects: patient-related factors (eg, general health status, smoking habits, and oral hygiene maintenance), implant and prosthesis characteristics (eg, dimensions, coating, and loading), and site characteristics (eg, bone quality and density, vertical and horizontal dimensions, soft tissue around the implant).

### Patient-Related Factors

Patient-related factors may have a major effect on the survival of replaced implants. Cluster failures were reported by Horwitz et al<sup>31</sup> and Schwartz-Arad et al,<sup>32</sup> who claimed that one-third of patients showing almost two-thirds of implant failures could imply a “cluster” behavior. Cluster failure was defined as more than one implant failure per patient, not necessarily in the same area or quadrant. Also, this failure cluster pattern was found to be evident in both the surgical and prosthetic phase, supporting the patients’ related etiology. Various systemic and environmental conditions might account for this, including smoking,<sup>33</sup> uncontrolled diabetes,<sup>34</sup> or periodontal disease.<sup>35</sup> Unfortunately, no clear data were stated in the included articles about the number of patients who had more than one implant replaced. Thus, the clinical outcome of these patients was unknown.

A multitude of studies reported a significantly lesser initial survival rate and further loss of implants in smokers. As a matter of fact, Schwartz-Arad et al demonstrated that smoking increased the risk of failure more than any other factor.<sup>36</sup> However, Kumar et al,<sup>37</sup> in an 18-month study, reported no statistically significant survival rates (97% and 94.4%) for smokers and nonsmokers. Likewise, in the studies upon reimplantation, smokers were reported to exhibit a similar survival rate in a second/third attempt, as did the nonsmokers. Nonetheless, a larger database will help to further clarify the question of the effect of smoking on these redo implants.

## Implant and Prosthesis Characteristics

Among the articles included, implants of similar or wider dimensions were used for reimplantation compared with the original failed ones. The majority of studies compared the distribution of replacement implants' length and diameter versus previous ones, and no significant differences were observed. Numerous studies reported that length and diameter did not play an important role, and suggested the fact that geometry and surface are crucial in the hierarchical process of osseointegration.<sup>38-41</sup>

Surface characteristics of replaced implants were also studied with regard to implant failures. Alsaadi et al<sup>16</sup> reported a poorer survival rate for machined surface implants that were inserted to replace failed implants (79.3%) compared with rough TiUnite surface implants that were inserted in similar sites with a significantly greater survival rate (96.5%;  $P < .05$ ). The result suggested that an improved implant surface experiences faster bone apposition and that this may offer a better prognosis when failed implants have to be replaced at the same site. This finding coincides with the results published in the systematic review by Esposito et al, stating that implants with smooth surfaces failed at earlier stages than implants with roughened surfaces.<sup>42</sup> Due to the dearth of histologic data on implant replacement, it is viable to extrapolate findings from reosseointegration into implant replacement. In a canine model, Levin et al aimed to evaluate the difference of reosseointegration potential between contaminated vs new implants. After retrieval of failed implants, contaminated implants were inserted into pristine sites and noncontaminated ones into peri-implantitis sockets. Interestingly, it was found that osseointegration seems to be achievable both in infected sites and around contaminated implant surfaces.<sup>43</sup> In contrast, Persson et al<sup>44</sup> reported that significant reosseointegration failed to occur for implant surfaces exposed to bacterial contamination following traditional treatment of peri-implantitis lesions.

The type of prosthesis plays an important role in long-term survival of implants; in a recent systematic review,<sup>45</sup> the connection type of the definitive restoration (cemented or screw retained) influenced the increased rate of fistula or suppuration in cemented reconstructions. Overloading is another factor that has been associated with implant failure.<sup>46</sup>

Only two articles reported implant failures after prosthetic loading (Kim et al<sup>20</sup> and Mardinger et al<sup>19</sup>) with 31.7% and 35% of failures, respectively; the connection type of the definitive restoration was not reported. Fu et al reported 16.6% of failures due to overloading; this finding coincides with other authors who considered occlusal overloading an important factor that may jeopardize implant survival.<sup>47</sup>

## Site Characteristics

The site-specific theory is mainly supported by the findings that failed implants are often found in patients where other implants were successfully osseointegrated and in function.<sup>48</sup> Several studies have addressed this topic, including differences between the maxilla and the mandible,<sup>49</sup> different sites (molars, premolars, and canine incisor regions),<sup>50</sup> and poor bone quality.<sup>51,52</sup> Also, site-specific factors include a simultaneous bone graft with survival rates of 92.2% or previous bone grafting,<sup>53</sup> sinus augmentation procedures with survival rates of 91.8%,<sup>54</sup> previous apical pathology,<sup>55</sup> and root-implant proximity.<sup>56</sup>

A failed implant site presents with reduced alveolar bone, horizontally and vertically. Bone loss is also greater around remaining implants in patients who lost implants after loading.<sup>7,57,58</sup> Machtei et al<sup>6</sup> suggested that the substantial negative effect of these sites outweighs the patients' and environmental variables and masks their effect. However, Levin et al<sup>43</sup> demonstrated good osseointegration for new implants placed in peri-implantitis sites (immediately following the retrieval of the old implants without any decontamination), despite the nature of these sites.

The need for ridge augmentation was reported to be 3%,<sup>17</sup> 25%,<sup>6</sup> 46%,<sup>19</sup> and 70%.<sup>20</sup> Correlation was found between the amount of bone loss and the need for local augmentation as expected. Nonetheless, after site augmentation, correlation was not found between the previous site bone loss and failure of the replaced implant.<sup>6</sup>

Information about implants' prosthetic connection (screw vs cemented), placement mode (submerged vs nonsubmerged), patients using antibiotics or not, and implant type (one-stage vs two-stage) was not clearly expounded in the articles included. This does not necessarily imply that the aforementioned variables are not risk factors in implant dentistry. Instead, further research with a larger cohort for a longer follow-up period is warranted to draw definite conclusions as to the influence of different factors on outcome of a redo implantation. Clinicians should remember that once an implant has failed, replacement of that implant is subjected to at least all the initial factors that led to the failure.<sup>7</sup>

On the basis of the analysis of the aforementioned risk factors, implant survival rates of replaced dental implants might be increased by retrieving the initial failed ones with meticulous removal of granulation tissue of the failure site together with the use of wider implants with improved (treated) surfaces. In an attempt to maintain the integrity of bone walls, implant extraction should be performed as gently as possible. In addition, the success of reimplantation might be increased by using various bone grafting techniques and/or additional implants when necessary.<sup>21,23</sup>

## Limitations and Further Directions

Due to the interstudy heterogeneity, a meta-analysis could not be conducted as part of this review. There are deviations from the methods of data collection and the subsequent analyses. There is still a lack of sufficient evidence-based data regarding implantation in previously failed sites. Further clinical studies, with more extensive clinical cases and a longer follow-up period, are required to obtain additional data on this procedure. The additional findings would provide clinicians with improved data for selecting the most appropriate treatment protocol for patients with failed implants.

## CONCLUSIONS

Implant replacement is a reasonably feasible option for scenarios of early and late implant failure. However, modifiable risk factors must be controlled before proceeding with implant replacement. Due to differences in study design and sample size, no direct conclusions can be drawn as to the influence of different factors on the success of reimplantation. However, there was a trend toward slightly higher survival rates for replaced implants with wider diameters and improved surfaces. Also, the success of implant replacement might be increased by meticulous removal of granulation tissue of the failure site, using various bone grafting techniques and/or additional implants when necessary.

## ACKNOWLEDGMENTS

This study was funded by the National Natural Science Foundation of China (81371190), Science and Technology Commission of Shanghai Municipality (13ZR1424000), the Combined Engineering and Medical Project of Shanghai Jiao Tong University (YG2012MS32;YG2014QN01). The authors reported no conflicts of interest related to the publication of this paper.

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