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Clinical Evaluation of Dental Implant Placement in Reconstructed Jaw Bones

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ABSTRACT

The purpose of the proposed multi-centre retrospective cohort study was to conduct a clinical and radiographic evaluation on dental implants outcomes in restored jaw bone. There were 72 patients who had undergone 180 implants and the follow up period was between 6 and 60 months. Imputed analysis was done to compare the survival, marginal bone loss (MBL), and outcome patterns with the reconstruction technique on an implant level. Surgery survival rates were high, as indicated by Kaplan Meyer review; nevertheless, there was a variation in survival rate of implants used in different types of reconstruction. Guided bone regeneration (GBR) sites with implants registered a cumulative survival of 100% then the autografts block reconstructions of the vascularized fibula flap (96.3%), with less portability of the block grafts vascularized fibula flapses after either tissue state recorded. Reconstruction techniques had different marginal bone losses. The median MBL of GBR, autogenous block grants and vascularized fibula flap were 1.19 mm, 1.27 mm and 1.80 mm respectively. Forty-three-point three percent of the implants had MBL value of only 1.5 mm and above and 17.2 percent had bigger values of 2.0 mm. Favourable correlation also indicated a positive association between the length of follow up and MBL with the site of vascularized fibula flaps portraying the highest rate of bone loss over time. In general, although the survival of implants in reconstructed jaw bones was usually positive, reconstruction technique and peri-implant bone stability were also affected by the time after which the implant was placed. Such results suggest that reconstruction-focused outcome measurement is essential during the implant rehabilitation planning process.

Keywords: Autogenous bone graft, Dental Implants, Guided Bone Regeneration, Implant survival, Marginal bone loss, Multi-center cohort study, Reconstructed Jaw Bone, Vascularized fibula flap

1 Introduction

DENTAL implant supported rehabilitation now tends to be seen as an important step in the process of returning oral function following jaw surgery since it is possible to restore mastication, speech support and prosthetic stability of reconstructed maxillary or mandibular sections using implants. Modern data of vascularized bone reconstructions demonstrate that the placement of the implant in reconstructed jaws can be performed with a fairly positive survival outcome, although the outcomes differ considerably between patient groups and clinical settings, especially in the presence of adjuvant radiotherapy. This heterogeneity is most evident with longer follow-up cohorts where both progressive bone-level changes and implant loss can develop over the years, as well as with longer follow-up cohorts, in which progressive bone-level changes can become evident over the same period [1–3].

Nevertheless, rebuilt jaw bone is not a piece of biology. It can be bone that has been made or grown up in a process like guided bone regeneration (GBR) or autogenous block grafting or it can be a removed bone flap with its vascular

attachment (e.g., free fibula flap). The different reconstruction routes give rise to the unique healing paths, remodeling pattern, and soft-tissue state that may affect the prospective status of peri-implant tissues and the long-term stability. Time management strategies (primary vs. secondary implant placement) have been investigated in vascularized fibula reconstructions in particular, suggesting that it is necessary to shorten rehospitalization days but cumulative evidence points to disparities in rates of survival and complications across studies and signals [4, 5].

In addition to implant survival, marginal bone loss (MBL) has emerged as an epic outcome such that it gauges peri-implant bone-level stability and provides the difference between criteria of survival and the success that is of clinical significance. Bone-level alterations at the early stage might have a prognostic value, and there is a growing literature suggesting that reporting on survival can confound pathological trends in a minor proportion of implants [6]. Simultaneously, there is long-term clinical support indicating that bone-level conduct might vary between implants put in augmented and non-augmented locations, which supports the argument that MBL should be regarded as a primary outcome as opposed to a secondary descriptive alternative [7]. Also, the peri-implant diseases and contractions are closely associated with the presence of various biological and prosthetic risks, making it important to think over uniform definitions and similar reporting across facilities especially in the more complex cases involving reconstructed structures where access to hygiene and soft-tissues can be at a disadvantage [8].

Even with the increased literature, clinical outcomes in reconstructed jaws remain consistently diverse in methodology: various categories of reconstruction are mixed together [9], the length of follow-up assessment, and outcome measurements (success vs. survival; the definitions of peri-implantitis cases; minimizing of MBL) remain inconsistently harmonized. With this heterogeneity, it becomes difficult to perform evidence-based decision-making into the choice of reconstruction methods, the timing of implants and risk stratification as well as weaknesses in the ability to compare outcomes between the hospitals and the implant centers and thus produce interpretable and clinically actionable evidence at this point [10].

2 Problem Statement

The use of dental implants on the rebuilt jaw bones is gaining acceptance at various clinical treatment centers and with the current mode of reconstruction as well as the rehabilitation procedures of the implants. Although this has increased, not all institutions evaluate and report such clinical outcomes as the survival of the implants, marginal bone loss, and peri-implant complications. The difference in data reporting forms, success and survival definition and follow-up procedures complicate comparison of the outcomes of the centers. This deficiency of multi-center aggregated data reduces the capabilities of making evidence-based decisions about which reconstruction type to be used and when the implant is to be placed. Further, lack of standardized, results-oriented visual representation decreases the degree of interpretation of the results and the complexity of the transfer of research to clinical application. Thus, it is apparent that there is a necessity of systematic assessment with combined outcome measures and sophisticated visualization tools to facilitate credible clinical prescriptions.

3 Aim of the Study

This study will be aimed at a clinical and radiographic assessment of the outcomes of dental implantation of reconstructed jaw bones through multi-centered retrospective cohort study.

4 Objectives

This study has the aims of determining both long-term patients of re-colored jaw bone, evaluating marginal bone erosion around the implant when used in various types of reconstruction, and evaluating peri-implant biological and mechanical problems. Also, the research aims at determining patient-related and procedure-related predictors of bad outcomes.

5 Research Questions

- How likely are dental implants to survive in bone reconstruction with lost jaw bones?
- What is the marginal bone loss depending on the type of reconstruction and the location of the jaw?
- What is the patient-related and procedural aspects that can be related to implant failure or peri-implant complications?

6 Research Hypotheses

- Implant survival very much depends on the reconstruction technique.
- The distribution of marginal bone loss differs between the different types of reconstruction.
- Smoking status and complex reconstruction procedures are shown to be risk factors for a higher incidence of peri-implant complications and implant failure.

7 Literature Review Framework

The biology of the reconstructed substrate (vascularized

and non-vascularized bone, cortical/cancellous bone composition, and remodelling) and the reconstruction pathway that is adopted to restore sufficient bone volume and functioning will determine clinical implant rehabilitation in re-created jaw bone [11]. The peri-implant bone behavior in relation to loading in vertical and/or guided bone augmentation may also vary among the techniques, and long-term comparative data show that the peri-implant bone loss varies depending on the augmentation modality and follow-up period, but the systematic evidence on the topic remains uneven across techniques [12]. In microvascular reconstruction mostly of fibula free flap-based rehabilitation, most recent syntheses note that prosthetic rehabilitation rates and narrowed oncology-based implant-assisted reconstruction are clinically feasible but still variably applied, often on oncology-reliant logistics as well as on digital addition and integration of planning [13]. Such technical amendments like the double-barrel fibula design have been examined and have yielded on average positive flap results and minimal implant failure rates, but lost aesthetic /functional endpoints and reporting criteria are still disparate [14]. There is also a theme of timing: the evidence comparing the instant and delayed installment of implants when reconstructing the fibula indicate that there might be benefits of implant survival and improvisation of complications in specific pathways, particularly in patients who might need to undergo radiotherapy [15]. In non-vascularized reconstruction based on extraoral autogenous grafts, there is generally high long-term survival of implants, and marginal bone loss is generally low, with only a handful of publications demonstrating any meaningful clinical impact of donor site or vascularization status-based clinically meaningful differences [16].

A key methodological cornerstone used in this field is the reliability and comparability of radiographic assessment of outcome, in particular of MBL. Contemporary reviews in radiology and periodontology have focused on showing how imaging modality choices, projection geometry, reference points, and calibration procedures can have a material effect on interpretation of the peri-implant bone level relative to the longitudinal comparability [17]. Meta-research further illustrates that even in recent controlled clinical trials, reporting of standardization steps of the radiography (e.g. use of positioners, anatomical references and consistent baseline definitions) is often incomplete - as a direct motive for a more stringent protocolization for MBL-measurement in multi-center datasets [18]. In addition to ensuring a rigorous measurement approach, clinical interpretation relies upon some standard definitions and risk stratification. Umbrella evidence supports strong association of peri-implantitis with established factors like smoking and history of periodontitis, but a number of other putative predictors are still supported by lower certainty evidence [19]. At the guideline level, structured supportive peri-implant management, early detection and standardized monitoring are becoming more important prerequisites for stable outcomes in complex cases in prevention and management frameworks. Collectively, these strands unfold a major issue: In spite of accumulating experience with implants-in-reified jaws, the legacy of cross-center heterogeneity in case definitions, really radiographic protocols, time of timing strategies, and report of outcomes enforcement provisions the process of decision making - supporting the rationale for a streamlined, multi-center evaluation with consolidated endpoints and visualization-support interpretability [20].

8 Methodology

8.1 Study Design

The study was a cohort retrospective study. To determine the results of dental implants on reconstructed jaw bones, clinical and radiographic measures were determined at the level of the implants. Multi-centric strategy was implemented to increase the external validity of the results and to be able to reflect the variation in the reconstruction methods, surgical procedures, and patient demographics in various clinical settings.

8.2 Study Setting

The outcomes of the study were done in four implant units and oral and maxillofacial surgery units in four hospitals. Jaw reconstructions are regularly performed in such centers with subsequent rehabilitation of the jaw supported by implants and they include a database of records and digital radiographic archives that assist in a consistent collection of retrospective data and comparative analysis.

8.3 Study Period

Dental implants used in this case were between 2019 and 2025. Follow-up period was different in all the implants because data collection was retrospective and cases accrued with time and therefore follow-up was as long as 6 months and not more than 60 months. This difference enabled evaluation of both the short-term and medium clinical and radiographic results, as shown in Table 1.

Table 1. Distribution of patients and implants among participating centers.

Participating center	Number of patients (n)	Number of implants (n)	Mean implants per patient
Center A	18	46	2.56
Center B	20	52	2.6
Center C	17	40	2.35
Center D	17	42	2.47

Total	72	180	2.5

8.4 Reconstruction Categories

Reconstructed jaw sites to be used in this study would be grouped in three broad categories of reconstruction with reference to the surgical procedure that would be applied to restore bone volume before or in combination with placing dental implants. The former included those sites that were reconstructed by the guided bone regeneration (GBR) method, which is usually targeted by localized horizontal and/or vertical alveolar defects. The second one consisted of sites that were reconstructed with autogenous block bone grafts that were obtained at intraoral or extraoral sources and were mostly used where there was moderate to severe ridge deficiency that needs a significant three-dimensional augmentation. The third group was those that were reconstructed with the vascularized fibula free flaps which is mostly used when there is a long period of segmental jaw defect after tumor removal or injury. This classification allowed to compare the implant outcomes in biologically and surgically different reconstruction modalities. Table 2 displays the distributive statistics of reconstruction techniques and their major clinical signs.

Table 2. Reconstruction techniques and indications included in the study.

Reconstruction technique	Patients (n)	Implants (n)	Primary clinical indications
Guided bone regeneration (GBR)	28	68	Localized alveolar defects; horizontal and/or vertical ridge deficiency
Autogenous block bone graft	24	54	Moderate–severe ridge atrophy requiring structural augmentation
Vascularized fibula flap	20	58	Extensive segmental jaw defects after tumor resection or trauma
Total	72	180	—

8.5 Inclusion and Exclusion Criteria

Inclusion criteria were that patients were 18 years of age or older and had dental implants placed in reconstructed jaw bone sites. Only cases with a minimum clinical and radiographic follow-up period of six months were considered for evaluation of implant survival and marginal bone loss to be evaluated in a meaningful fashion. Furthermore, inclusion required the available standardized radiographic records suitable for longitudinal assessment of peri-implant crestal bone levels.

Patients were excluded from the study if there were missing clinical or radiographic data. Cases where the follow-up period was observed for less than 6 months were excluded because of a lack of time to assess the outcomes. In addition, unsuitable and accidentally unsuitable radiographs for accurate measuring of the marginal bone loss were excluded from the analysis (unsuitable criteria included poor image quality and lack of standardized projection). A summary of inclusion and exclusion criteria used in this study is given as Table 3.

Table 3. Baseline characteristics according to reconstruction technique.

Variable	GBR (n = 28)	Block graft (n = 24)	Fibula flap (n = 20)	p-value
Mean age (years)	46.2 ± 11.4	49.8 ± 10.7	54.3 ± 9.6	0.041
Male sex (%)	15 (53.6%)	13 (54.2%)	14 (70.0%)	0.38
Smoking (%)	6 (21.4%)	7 (29.2%)	9 (45.0%)	0.048
Mandibular reconstruction (%)	12 (42.9%)	14 (58.3%)	18 (90.0%)	<0.001
Delayed implant placement (%)	10 (35.7%)	13 (54.2%)	17 (85.0%)	<0.001
Mean follow-up (months)	28.6 ± 11.2	31.4 ± 12.5	33.8 ± 13.1	0.29

8.6 Study Variables

The study variables were defined in order to fully assess clinical and radiographic outcomes of dental implants placed in reconstructed jaw bones. Patient-related variables included basic demographic characteristics in order to allow contextual interpretation of outcomes. Procedure-related variables included the reconstruction technique used, the implant site characteristics and the time of implant placement in relation to the reconstruction procedure. Follow-up time for each implant was noted to adjust for differing periods of observation for all subjects in retrospective cohort studies. Outcome variables were implanting survival status, marginal bone loss including radiographic lesion, incidence of biological or mechanical complications at the implant site. Collectively these variables allowed analysis at the implant level of performance, stability and risk factors in different reconstruction modalities. Detailed summary of study variables, their operational definitions and the measurement methods used is presented in Table 4.

All the implants used in the study were root-form titanium dental implants that were installed following standard surgical procedures as practiced in each of the centers. The size of the implants such as length and diameter were determined according to clinical needs and

reconstructed bone volume.

Table 4. Summary inclusion and exclusion criteria.

Category	Criteria description
Inclusion criteria	
Age	Patients aged 18 years or older
Implant site	Dental implants placed in reconstructed jaw bone
Follow-up duration	Minimum of 6 months
Radiographic data	Availability of standardized radiographic records
Exclusion Criteria	
Data completeness	Incomplete clinical or radiographic records
Follow-up duration	Less than 6 months
Radiographic quality	Radiographs unsuitable for marginal bone loss measurement

8.7 Radiographic Assessment Protocol

A standardized radiographic protocol was used to measure the marginal bone loss around dental implants that were inserted in reconstructed jaw bones. For each implant, the first radiographic image taken during prosthetic loading or one of the first radiograph images obtained immediately after the implant placement if a loading radiograph was not available, was defined as a baseline radiograph. Follow up radiographs drawn from most up-to-date imaging records (standardized) obtained on routine clinical review. No lean tissue positioned between the source and detector and no misplaced roots included only radiographs with sufficient image quality and a consistent projection geometry were included in the analysis.

Mesial and distal crestal bone levels for each implant were measured using clearly defined reference points extending from the implant-abutment junction and-contact bone to the first bone-implant contact. Measurements were made on calibrated digital radiographs so accuracy of measures in metric is ensured. The values of mesial and distal were taken in average to obtain one value of marginal bone loss for each implant so to be able to compare in a standardized way among implants and reconstruction categories.

To be sure the measurement is as reliable as possible, all the radiographic assessments were done by a single calibrated examiner. Intra-examiner reliability was assessed by repeating measurements on a randomly selected subset of radiographs after 2 weeks, and inter-measurement of the measurements was assessed to insure consistency of the radiographic evaluation protocol. A summary of the standardized radiographic assessment protocol used in this study is given in Table 5.

Table 5 Study variables, operational definitions, and measurement methods.

Variable category	Study variable	Operational definition	Measurement method
Patient-related variables	Age	Patient age at the time of implant placement	Extracted from medical records (years)
	Sex	Biological sex of the patient	Medical records (male/female)
Procedure-related variables	Reconstruction technique	Type of jaw reconstruction performed prior to or with implant placement	Classified as GBR, autogenous block graft, or vascularized fibula flap
	Implant site	Anatomical location of the implant	Maxilla or mandible; reconstructed segment
	Implant timing	Timing of implant placement relative to reconstruction	Simultaneous or delayed placement
Follow-up variable	Follow-up duration	Time from implant placement to last clinical evaluation	Recorded in months
Outcome variables	Implant survival status	Presence of the implant in situ at last follow-up	Dichotomous outcome (survived / failed)
	Marginal bone loss (MBL)	Radiographic change in crestal bone level around the implant	Measured in millimeters on standardized radiographs
	Peri-implant complications	Biological or mechanical adverse events affecting the implant	Clinical and radiographic diagnosis

A standardized digital periapical radiograph in the long-cone paralleling technique was used to obtain all radiographic measurements with minimal distortion and reproducibility. Image analysis and marginal bone level were measured in ImageJ software (National Institutes of Health, USA). The measurements were calibrated using the known length of implants to translate the pixel values into millimeters and obtain accuracy in the measurements.

8.8 Data Collection Procedure

Clinical data were retrospectively obtained from medical records of patients from each of the participating centers. Extracted variables were demographic data, reconstruction technique, implant-related data, follow-up period, and reported clinical outcome. Digital radiographs were retrieved from the electronic imaging archives of the oral and maxillofacial surgery and implant dentistry units by ensuring that only standardized and diagnostically adequate images were included.

Clinical data was retrospectively collected from medical records of patients from each of the participating centers. Extracted variables included demographic information, reconstruction method, implant-related information, follow-up period and reported clinical outcome. Digital radiographs were obtained from the electronic images in the oral and maxillofacial surgery and implant dentistry units files by making sure that only standardized and diagnostically adequate images are included, as shown in Table 6.

Table 6 Standardized radiographic protocol of marginal bone loss measurement.

Protocol component	Description
Baseline radiograph	First radiograph obtained at implant placement or at prosthetic loading
Follow-up radiograph	Most recent standardized radiograph available during follow-up
Reference points	Implant–abutment junction to first bone-to-implant contact
Measurement sites	Mesial and distal aspects of each implant
Measurement unit	Millimeters (mm)
Data processing	Mean of mesial and distal measurements per implant
Examiner calibration	Single calibrated examiner
Reliability assessment	Repeated measurements on a subset of radiographs

8.9 Statistical Analysis Plan

Statistical analysis was conducted at the implant level using appropriate statistical analysis methods. Descriptive statistics were calculated to summarize demographic characteristics, reconstruction techniques, follow up duration and implant related outcomes. Data of continuous variables were presented as mean ± standard deviation or median (interquartile range) according to distribution, and that of categorical variables were given as frequencies and percentages.

Implant survival over time was assessed with Kaplan-Meyer survival analysis and differences between categories of reconstruction assessed with log-rank test.

Comparative analysis of marginal bone loss (MBL) in each of the reconstruction techniques was performed using one-way analysis of variance (ANOVA) or Kruskal-Wallis test as appropriate. Post hoc pairwise comparisons when statistically significant differences were found.

In order to find independent predictor(s) of implant failure, Cox proportional hazards regression analysis was conducted. Variables that were inputted into the model were reconstruction technique, duration of follow-up, smoking status, jaw location (maxilla/mandible), and implant timing (simultaneous/delayed).

In addition, multivariable linear regression analysis was performed to find predictors of exacerbation of marginal bone loss. A p-value of < 0.05 was considered statistically significant.

9 Results

A total 72 patients with 180 dental implants placed in the reconstructed jaw bones were included in the analysis. Follow-up periods were between 6 and 60 months. Implant-level analysis was conducted to assess survival results, marginal bone resorption and correlation with reconstruction technique and follow-up period.

9.1 Implant Survival According to Reconstruction Technique

Kaplan-Meier survival analysis showed high overall implant survival in all the reconstruction categories over the follow-up period. The survival probabilities, however, varied from one technique to another.

Implants that were placed in sites reconstructed with guided bone regeneration (GBR) had the highest cumulative survival rate (100% at the end of follow-up). Implants in autogenous block graft - reconstructed sites had a cumulative survival rate of 96.3%. In contrast, implants in vascularized fibula flap reconstruction showed lower cumulative survival, which was 87.9% with time.

The separation between survival curves was more apparent after about 20-30 months of follow-up and the decline was more marked in the vascularized fibula flap group in comparison to the other reconstruction categories (see Figure 1).

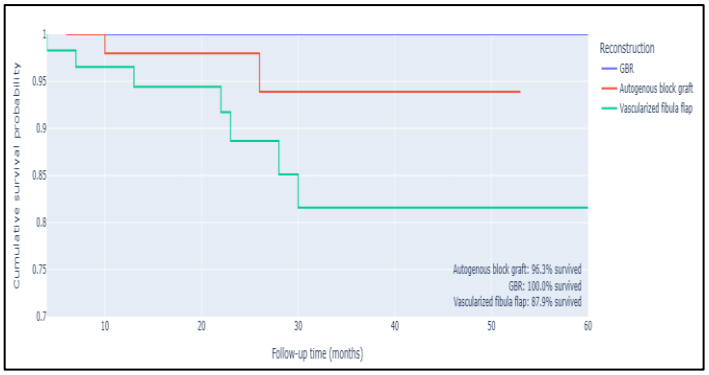

Fig. 1. Kaplan–Meier survival curve of dental implants according to reconstruction technique.

9.2 Marginal Bone Loss Distribution Across Reconstruction Categories

Marginal bone loss (MBL) was different depending on the reconstruction technique. The median MBL was least in the GBR group (1.19 mm) and the autogenous block graft group (1.27 mm) and the vascularized fibula flap group showed the highest median MBL (1.80 mm).

The vascularized fibula flap group also demonstrated greater variation in values and more than doubling the interquartile range with several implants of more than 2.5 mm and some approaching 4.0 mm. In comparison, GBR and autogenous block graft groups showed more compact distributions, where the majority of implants were clustered within any range approximately within 0.8 mm - 1.6 mm (Figure 2).

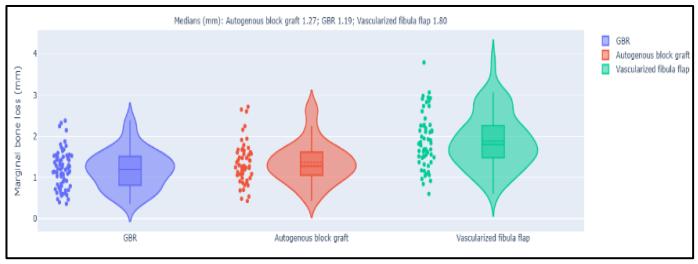

Fig. 2. Distribution of marginal bone loss across reconstruction categories.

9.3 Implant-Level Marginal Bone Loss Ranking

When the value of marginal bone loss was ranked in ascending order in the whole of the 180 implants, a progressive distribution pattern was noted. Most implants had marginal bone loss values of less than 1.5 mm. However, 78 implants, or 43.3%, demonstrated MBL ≥1.5 mm and 31 implants or 17.2% demonstrated MBL >=2.0 mm.

A smaller subset of implants demonstrated significantly increased bone loss values and came close to 3.0-4.0 mm, which is at the higher end of the distribution range. The curve showed a slow rising through most implants and then a steeper addition among the highest ranked implants suggesting the presence of a small, disproportionately higher subgroup of marginal bone loss (Figure 3).

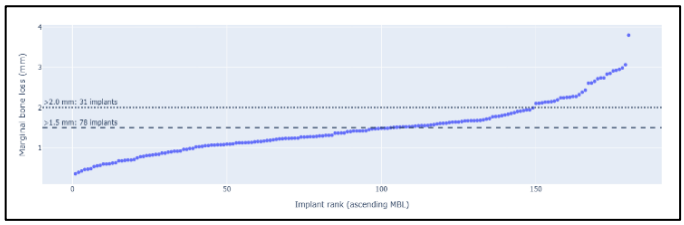

Fig. 3. Ranked implant-level marginal bone loss (all implants).

9.4 Relationship Between Follow-Up Duration and Marginal Bone Loss

A positive association between follow-up period and marginal bone loss at the implant level was found. Marginal bone loss increased with increasing time of follow-up in all the categories of reconstruction.

Among implants with at least 12 months of follow-up the mean MBL was 1.25 mm for the GBR group and 1.42 mm for the autogenous block graft group. The vascularized fibula flap group had the highest mean MBL of 1.94 mm.

Trend analysis revealed a steeper rise in bone loss over time at vascularized fibula flap reconstruction sites as compared to GBR and autogenous block graft reconstruction sites. GBR had the slowest progression pattern (Figure 4).

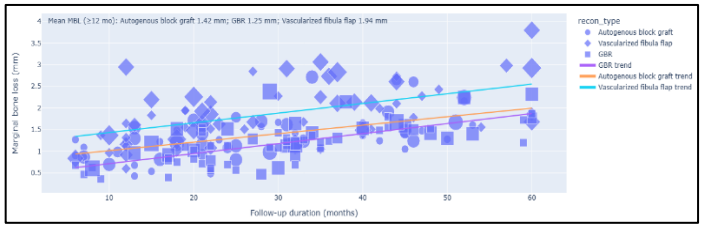

Fig. 4. Relationship between follow-up duration and marginal bone loss at implant level.

Collectively, the findings suggest that while implant survival was high across reconstruction of jaw bones, both the probability of survival and marginal bone stability depended on reconstruction technique. Vascularized fibula flap reconstructions had cumulative survival rates and greater marginal bone loss than those with GBR and autogenous block graft reconstructions. Additionally, the amount of bone loss has been shown to increase with longer follow-up duration and a clinically relevant percentage of implants had bone loss that surpassed commonly referenced bone loss thresholds.

The level of analysis and recording of peri-implant complications was at the level of implants. Of the total

number of implants (28) that exhibited at least one complication, 15.6% exhibited more than one complication. The most common biological complications were found in 19 implants (10.6 percent) and included peri-implant mucositis and peri-implantitis. In 9 implants (5.0), mechanical complications (loosening of screws, and prosthetics) were reported.

When stratified in terms of the reconstruction technique, more frequent occurrence of complications was found in the case of implants during vascularized fibula flap reconstructions than in the case of GBR and autogenous block grants.

Cox proportional hazards regression was carried out to determine the independent predictors of implant failure. It was found that smoking status had a strong correlation with the risk of implant failure (HR = 2.31, 95% CI: 1.12 - 4.76, p = 0.02). Moreover, the risk of failure was much higher in implants in a vascularized fibula flap reconstruction than in other reconstruction methods (HR = 2.85, 95% CI: 1.34-6.05, p = 0.01).

Age, sex, and implant location (maxilla vs. mandible) were other variables that were not significantly related to the failure of implants in the adjusted model.

Schoenfeld residuals were used to test the proportional hazards assumption, which was not violated.

10 Discussion

The current multi-center retrospective cohort research indicated a high overall survival of dental implants done in reconstructed jaw bones, which showed significant differences with the type of reconstruction technique undertaken. Implants implanted in locations that had undergone guided bone regeneration (GBR) had the highest survival rates and then autogenous block grants and finally vascularized fibula flap reconstructions had relatively lower survival rates in the long term.

These results are also in agreement with other earlier studies that have shown positive results with implants set in augmented alveolar bone, where the vascular supply and the size of defects is more regulated. Conversely, the observed relatively lower survival rates in the vascularized fibula flap reconstructions could be explained by the complexity of the reconstructed bone, altered biomechanics, and cortical bone structure and remodeling patterns variations.

The marginal bone loss (MBL) was determined to differ significantly among the reconstruction methods with the highest values recorded in the vascularized fibula flap. This finding is in line with the existing literature which indicates that peri-implant bone stability is mainly dependent on the quality of bone, its vascularization and the condition of soft tissue. Also, the gradual rise in MBL with time that was found in the current research justifies the need of long-term follow-up, particularly with the complicated cases that have undergone reconstruction.

This is further underscored by the fact that there are peri-implant complications which further point to the clinical difficulties that come with the placement of implants in reconstructed jaws. The increased complication rates of fibula flap reconstructions can be associated with the biological and prosthetic factors such as the ease of hygiene, soft tissue management, and load distribution. Clinically, it highlights the need to perform reconstruction-focused treatment planning and risk assessment. The clinicians ought to take into consideration the kind of reconstruction, patient related aspects including smoking and the time in which implant is to be placed when providing implant rehabilitation in reconstructed jaws.

11 Conclusion

Within the limitations of this multi-center retrospective cohort study, dental implant placement in reconstituted jaw bones showed generally positive clinical results. Implant survival was high for all categories of reconstruction; however, probability of survival depended upon reconstruction technique. Guided bone regeneration sites showed the highest cumulative survival, and were followed by the tea reconstructions and there was comparatively less survival at vascularized fibula flap reconstructions at medium term follow-up.

Marginal bone loss varied from reconstruction modality to reconstruction modality with vascularized fibula flap-reconstructed sites having higher median bone loss and greater variability. A clinically relevant percentage of the implants showed more than commonly referenced margins of bone loss. Additionally, there was an increasing degree of marginal bone loss with longer follow-up duration with a steeper trend observed in vascularized fibula flap reconstruction.

Overall, the results show that reconstruction technique is a meaningful factor in implant survival probability, as well as in peri-implant bone stability. These results support the need of reconstruction specific risk assessment and followed up protocols when considering implant rehabilitation for reconstructed jaws. Future prospective studies with longer durations of observation are recommended to further delineate the long-term outcomes and help guide optimal clinical decision-making.

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