Original Article

Delayed Versus Immediate Mandibular Reconstruction: A Retrospective Cohort Study

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ABSTRACT

Background: The optimal timing of mandibular reconstruction is debated, as immediate surgery may increase complications, while delayed reconstruction faces challenges. Comparative evidence on complication rates between the two approaches remains limited.

Purpose: This study compared complications between immediate and delayed mandibular reconstruction after tumor resection.

Materials and Method: A retrospective cohort of 70 patients who underwent reconstruction at Shahid Beheshti University of Medical Sciences (May 2015–April 2024) was analyzed. Patients were divided into immediate reconstruction (simultaneous with resection) and delayed reconstruction (more than two months post-resection). Data on demographics, smoking, radiation history, defect size, graft type, and pathology were collected. Postoperative complications, including dehiscence, infection, and graft loss, were evaluated. Statistical analysis was conducted using SPSS, with significance set at *p* Value <0.05.

Results: No significant differences were observed in age, gender, defect size, graft type, or radiation exposure between groups. However, dehiscence was significantly more common in the immediate group (45.7%) compared to the delayed group (20%) (p= 0.04). Infection (17.1% *vs* 8.6%) and graft loss (14.3% *vs* 5.7%) were higher in the immediate group but not statistically significant (p> 0.05). Smoking and radiation exposure significantly increased the risks of dehiscence and graft failure.

Conclusion: While immediate reconstruction offers timely restoration, it is associated with a higher dehiscence rate. These findings emphasize tailoring treatment plans based on patient-specific factors, particularly smoking and radiation history, to improve outcomes in mandibular reconstruction.

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Introduction

Mandibular reconstruction aims to restore function, aesthetics, and continuity, ensuring a comprehensive and effective outcome [1]. For years, the timing of bony jaw reconstruction following tumor resection has been a topic of debate. Current treatment approaches are divided into immediate (one-step) and staged/delayed (two-step) reconstruction, influenced by factors such as the local condition, the nature of the deformities (whether bony, soft tissue, or both), the type of injuries (trauma, gunshot wounds, benign or malignant pathology), the type of defect (with or without continuity), the quality of the donor site, the patient's overall health and prognosis, and the surgeon's expertise [1-3]. It is important to distinguish between maxillary and mandibular reconstruction, as the functional rehabilitation of the mandible can often be achieved primarily through bridging osteosynthesis and the use of a soft tissue flap [2-3].

Immediate reconstruction offers several advantages, including sufficient tension-free soft tissue, easier placement and shaping of the bone graft, improved mandibular contouring, and a reduction in both the number of surgeries and overall treatment time [4]. In cases where there is a significantly elevated anesthesia risk due to extensive cardiovascular comorbidities, primary reconstruction is always preferred to prevent the need for a secondary procedure [5]. Additionally, it has been shown that immediate non-vascular bone grafts have an acceptable success rate for defects smaller than 6cm [6]. In the context of delayed reconstruction, factors such as scarring from previous surgeries, insufficient recipient vessels for vascular grafts due to sacrifice during the initial procedure, and radiation exposure may limit treatment outcomes [7].

Delayed reconstruction is often recommended for malignant lesions to monitor for tumor recurrence. However, some studies have suggested that immediate reconstruction does not increase the risk of recurrence [8-9]. The decision between immediate and delayed reconstruction is mainly influenced by the individual's specific local findings, the probability of achieving a margin-free resection, and the patient's preferences and overall health condition. Thus, there is no strict algorithm for determining whether to pursue an immediate or delayed approach in the decision-making process [5].

Surgeons have long been concerned about the success rates of immediate reconstruction [10], which has gained popularity due to the use of osteocutaneous flaps that allow for simultaneous restoration of hard and soft tissues [11-12]. There are few studies comparing immediate and delayed mandibular reconstruction [6, 10, 13].

The aim of the study is to investigate the prevalence of complications associated with both approaches, hypothesizing that immediate reconstruction may have a higher complication rate than delayed reconstruction.

Materials and Method

This retrospective cohort study examined patients who underwent mandibular reconstruction at Shahid Beheshti University of Medical Sciences between May 2015 and April 2024. The study protocol received approval from the medical ethics committee of Shahid Beheshti University of Medical Sciences (IR.SBMU. DRC.REC.1402.121).

The sample size was calculated using formula 1, based on results from a similar previous study [14], assuming test value of the difference in complication rate 0%, anticipating a complication rate of 5% and 15% for the study groups, to achieve a power of 90% and a confidence interval of 95%, a total of 35 patients was determined to be necessary in each group.

Formula 1: $N = \left(\frac{Z_{1-\alpha/2}\sqrt{2P(1-P)}+\sqrt{P1(1-P1)P2(1-P2)}}{(p1-p2)^2}\right)^2$

Eligible participants included patients with benign or malignant lesions requiring mandibular resection, who underwent reconstruction with autogenous bone grafts either immediately or at a later date. Immediate reconstructions were performed through a combination of intraoral and extraoral access and delayed reconstructions through an extraoral access. Exclusion criteria consisted of prior reconstructions (successful or unsuccessful), diabetes, recurrence of the lesion, and lack of follow-up attendance. Although follow-up intervals varied slightly due to the retrospective nature of the study, only patients with at least 12 months of postoperative follow-up were included. Clinical complications were assessed within this standardized minimum follow-up period to minimize temporal bias and account for the spontaneous resolution of transient postoperative complications.

An oral and maxillofacial surgeon reviewed patient records. The data collected included age, gender, smoking status, history of radiation, defect size (measured via computed tomography scan), donor sites (anterior iliac crest or fibula), type of grafts (free bone graft or vascularized graft), and pathology types (benign or malignant). An orthopantomogram (OPG) was performed on all patients during the final follow-up. Surgical outcomes were assessed clinically, with a focus on complications such as dehiscence (reopening of the primary incision site), infection (indicated by redness, purulent discharge, or swelling days after surgery), and graft loss (exposure of grafted bone leading to necrosis or nonvitalization of the graft).

Immediate reconstruction was defined as the simultaneous resection and reconstruction of the mandible, whereas delayed reconstruction referred to procedures conducted more than two months after resection to facilitate soft tissue healing.

Statistical analyses were conducted using statistical package for the social sciences (SPSS) version 22 for PCs (IBM, USA). The chi-square test was employed to

Table 1: Description of the studied variables and comparison between the immediate and delayed reconstruction groups (n: number; SD: standard deviation)

Variables		Total (n=70)	Group I (immediate) (n=35)	Group II (delayed) (n=35)	*p* Value
Age (mean±SD)	Year	46.63±13.03	46.51±12.78	46.74±13.47	0.94*
Gender (n)	Male	45	24	21	0.62**
	Female	25	11	14	
Donor sites (n)	Iliac	59	31	28	0.78**
	Fibula	11	4	7	
Graft type (n)	Free bone grafts	52	25	27	0.78**
	Vascular grafts	18	10	8	
Defect size (mean±SD)	Centimeter	5.79±1.10 (4-8)	5.8±0.93	5.7±1.24	0.91*
Smoking (n)	No	46	20	26	0.28***
	Yes	24	15	9	
Received radiation (n)	No	56	28	28	1.00**
	Yes	14	7	7	
Pathology type (n)	Benign	47	20	27	0.13***
	Malignant	23	15	8	
Post-operative infection (n)	No	16	29	32	0.48***
	Yes	9	6	3	
Graft loss (n)	Graft survived	63	30	33	0.43***
	Graft loss	7	5	2	
Dehiscence (n)	No	47	19	28	0.04***
	Yes	23	16	7	

*Independent samples T-test, **Chi-square test, ***Fisher's Exact Test

assess the frequency of variables between the two groups. Odds ratios (OR) were calculated to determine the risks associated with the variables. An independent samples t-test was used to compare age and defect size between the groups. A significance level set at *p* Value < 0.05.

Results

Seventy participants (35 in each group) were initially enrolled in the study. There were no statistically significant differences in the studied variables between the two groups (*p* Value> 0.05), except for dehiscence (*p*= 0.04). The frequency of dehiscence was 45.71% in Group I (immediate reconstruction) and 20% in Group II (delayed reconstruction). Regarding post-operative infection, 17.14% of patients in Group I and 8.57% in Group II experienced infections. Additionally, graft loss occurred in 14.29% of patients in Group I and 5.71% in Group II. No significant differences were found in the frequencies of post-operative infection and graft loss between the two groups (*p*= 0.48 and *p*= 0.43, respectively). Table 1 summarizes the baseline demographic and clinical characteristics of the study participants and compares the two groups.

Table 2 presents the comparison of variables between patients with and without dehiscence.

Table 2: Comparison of variables between the patients with and without dehiscence (n: number; SD: standard deviation)

Variables		With dehiscence (n=23)	Without dehiscence (n=47)	*p* Value
Age (mean±SD)	Year	48.30±11.89	45.80±13.61	0.46*
Gender (n)	Male	15	30	0.56**
	Female	8	17	
Donor sites (n)	Iliac	20	39	0.48**
	Fibula	3	8	
Graft type (n)	Free bone grafts	17	35	0.59**
	Vascular grafts	6	12	
Defect size (mean±SD)	Centimeter	5.78±1.04	5.78±1.12	0.98*
Smoking (n)	No	1	45	<0.001**
	Yes	22	2	
Received radiation (n)	No	10	46	<0.001**
	Yes	13	1	
Pathology type (n)	Benign	7	40	<0.001**
	Malignant	16	7	

* Independent samples T-test, **Fisher's Exact Test

Table 3: Comparison of variables between the patients with the graft loss and successful graft (n: number; SD: standard deviation)

Variables		Graft loss (n=7)	Graft succeeds (n=63)	*p* Value
Age (mean±SD)	Year	43.28±12.31	47±13.15	0.46*
Gender (n)	Male	4	41	0.69**
	Female	3	22	
Donor sites (n)	Iliac	6	53	0.7**
	Fibula	1	10	
Graft type (n)	Free bone grafts	5	47	0.58**
	Vascular grafts	2	16	
Defect size (mean±SD)	centimeter	6.00±1.00	5.76±1.10	0.58*
Smoking (n)	No	1	45	<0.001**
	Yes	6	18	
Received radiation (n)	No	1	55	0.005**
	Yes	6	8	
Pathology type (n)	Benign	0	47	<0.001**
	Malignant	7	16	

* Independent samples T-test, **Fisher's Exact Test

The results indicated statistically significant differences in the frequency of smokers, patients who received radiation, and pathology type (benign or malignant) between the two groups (all $p< 0.001$).

Evaluation of the impact of smoking on dehiscence revealed that smoking increased the risk of dehiscence by 15 times in both immediate and delayed reconstruction patients (OR: 15, 95% CI: 1.68–133.55). The risk of dehiscence was found to be 59.8 times higher in patients who received radiation compared to those who did not (OR: 59.8, 95% CI: 6.99–511.24). Additionally, the type of pathology increased the risk of dehiscence by 13.06 times in the malignant group compared to the benign group (OR: 13.06, 95% CI: 3.94–43.25). Table 2 presents the comparison of variables between patients with and without dehiscence.

The data analysis revealed that smoking increased the risk of graft loss by 15 times compared to non-smokers (OR: 15, 95% CI: 1.68–133.55). Similarly, radiation exposure was associated with a 41.25 times greater risk of graft loss compared to patients who did not receive radiation (OR: 41.25, 95% CI: 4.38–388.69). Table 3 summarizes these findings.

Smokers had a 22.5 times higher risk of post-operative infection compared to non-smokers (OR: 22.5, 95% CI: 2.60–194.26). Additionally, patients who underwent radiotherapy faced a 73.33 times greater risk of post-operative infection than those who did not receive radiotherapy (OR: 73.33, 95% CI: 7.78–691.02). Table 4 presents the comparison between infected and non-infected patients.

Discussion

The time-frame for mandibular reconstruction presents a significant challenge in the treatment sequence. The primary goal of reconstruction is to restore both function and aesthetics, meaning that simply filling the defect with bone or a bone substitute is inadequate [15].

Table 4: Comparison of variables between post-operative infected and non-infected patients (n: number; SD: standard deviation)

Variables		Infected (n=9)	Non-infected (n=61)	*p* Value
Age (mean±SD)	Year	40.88±11.80	47.47±13.08	0.16*
Gender (n)	Male	6	39	0.69**
	Female	3	22	
Donor sites (n)	Iliac	8	51	0.60**
	Fibula	1	10	
Graft type (n)	Free bone grafts	7	45	0.58**
	Vascular grafts	2	16	
Defect size (mean±SD)	Centimeter	5.77±1.09	5.78±1.09	0.98*
Smoking (n)	No	1	45	<0.001**
	Yes	8	16	
Received radiation (n)	No	1	55	<0.001**
	Yes	8	6	
Pathology type (n)	Benign	0	47	<0.001**
	Malignant	9	14	

* Independent samples T-test, **Fisher's Exact Test

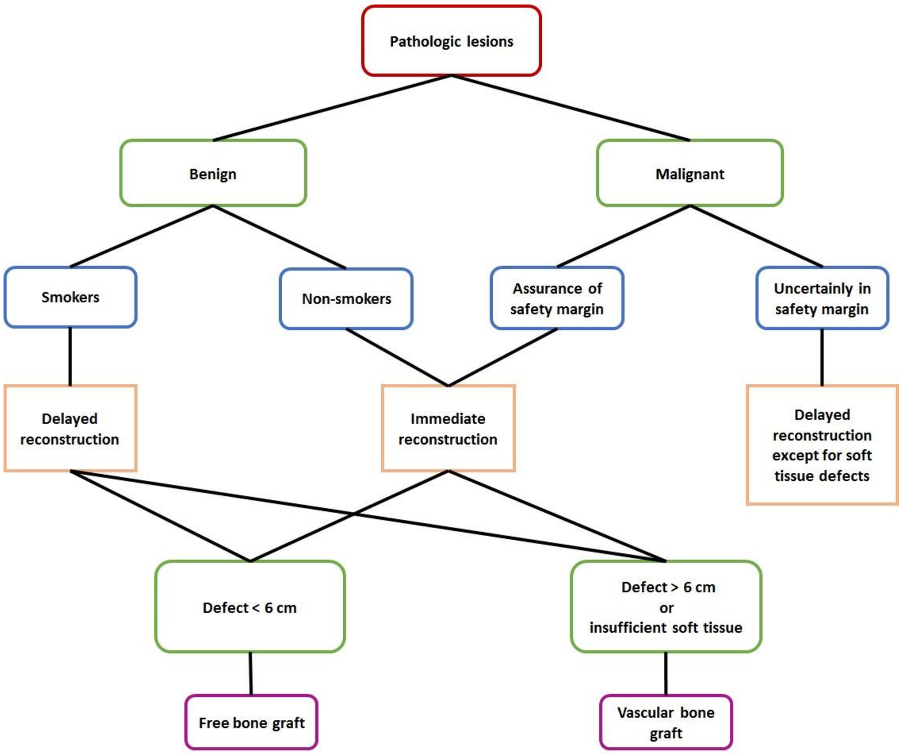

Figure 1: Proposed treatment algorithm for the management of mandibular defects caused by pathological lesions

This study aimed to compare the prevalence of complications associated with immediate versus delayed reconstructions. Additionally, the authors evaluated covariates such as smoking, radiation exposure, types of grafts, and the lesion pathology type (benign or malignant). Their objective was to develop a treatment protocol that minimizes complications while identifying potential risk factors. The two studied cohorts showed nearly identical average ages and a frequency distribution that favored male patients.

The results regarding graft loss indicated that there was no statistically significant difference in the success rates of immediate (85.71%) and delayed reconstruction (94.28%). The absence of a statistically significant difference in graft survival between immediate and delayed reconstruction may be attributed to careful patient selection and the use of standardized surgical protocols in both groups. Similar findings have been reported by previous retrospective study [5], suggesting that reconstruction timing alone may not be the primary determinant of graft survival, while host-related factors and tissue quality may have greater influence [5]. The results of a meta-analysis showed success rates of 95% (range: 93%–100%) for primary implant surgeries and 91% (range: 83%–100%) for secondary implant surgeries [16]. In another meta-analysis, the survival rate for immediate implantation was reported at 98% (95% CI: 94% to 100%), while the rate for delayed implantation was 97% (95% CI: 90% to 99%) [17].

Delayed mandibular reconstruction was associated with a lower dehiscence rate (20%) compared to immediate reconstructions (45.71%). Dehiscence can occur due to various factors, including inadequate soft tissue coverage, tension on the wound edges, and infection [15]. The higher dehiscence rate observed in the immediate reconstruction group may be related to increased soft tissue manipulation during simultaneous tumor resection and reconstruction. Larger soft tissue defects, increased wound tension, and compromised local vascularity may collectively contribute to impaired wound healing. This condition can lead to the exposure of underlying bone or reconstruction plates, compromising the healing process and increasing the risk of infection [15].

The results indicated that donor site and graft type did not significantly affect the success of the grafts. The choice between free bone grafts and vascular grafts depends on factors such as the size of the defects, soft tissue deficiency in either immediate or delayed reconstruction, and the vascular supply of the recipient site, which may be compromised due to previous radiation or excessive scarring [18].

Malignant pathological types significantly increase the risk of graft failure. Factors contributing to this higher failure rate include the sacrifice of hard and soft tissue to achieve a safety margin, a higher recurrence rate of malignant lesions, and the potential need for postoperative radiation [9]. Murugan *et al.* [19] found that malignant lesion was significantly associated with every complication such as flap failure, fistulas, dehiscence, bone exposure except for plate fracture.

In the current study, the two main factors affecting the failure of immediate or delayed mandibular reconstruction were radiation and smoking. The risk of dehiscence was found to be higher in smokers compared to non-smokers, as nicotine has detrimental effects on bone healing [20]. Nicotine is well-known to cause vasoconstriction, further reducing oxygen supply to grafts and soft tissues [21]. Similar studies have demonstrated the association between smoking and tobacco use with mandibular reconstruction [19, 22].

Radiation significantly damages the vascular system, impairing blood supply and reducing oxygen delivery to the irradiated mandible [23]. It is believed that osteoclastic giant cells are more negatively affected by irradiation than the vascular system itself. Additionally, an increase in myofibroblasts and a decrease in proliferative fibroblasts contribute to tissue injury [24]. A systematic review by Ardisson *et al.* [16] on the success rates of mandibular implants placed in vascularized fibula bone grafts found that implant survival in irradiated patients was generally lower (76%; range: 38%–88%) compared to nonirradiated patients (90%; range: 83%-94%). Despite inconsistencies in the literature, several studies have found no significant effect of direct adjuvant radiation exposure on flap survival [5, 14, 17, 25].

Based on the study results and the authors' experience, a treatment algorithm is proposed for managing mandibular defects due to pathological lesions (Figure 1).

This study was a retrospective cohort analysis; however, there was insufficient data on the dose and duration of radiation for patients who received radiation therapy. Additionally, the frequency of patients with malignant lesions in the immediate group (42.86%) was higher than the delayed group (22.86%), although this difference was not statistically significant. These limitations should be acknowledged.

The relatively small number of patients with malignant lesions was as a limitation of the present study, which limited subgroup analyses according to oncologic treatment modalities such as radiotherapy or chemotherapy. Future prospective studies with larger oncologic cohorts are needed to better evaluate these factors.

Conclusion

Immediate mandibular reconstruction does not significantly differ from delayed reconstruction in terms of graft survival, but it is associated with a higher rate of dehiscence. Smoking and prior radiation therapy significantly impact the success of reconstruction. These findings highlight the need for individualized treatment plans considering patient-specific risk factors, such as smoking and radiation history, to optimize outcomes.

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Patient consent

Informed consent was obtained from all individual participants included in the study.

Author contributions

Reza Tabrizi: Conceptualization, Methodology, Resources, Supervision. Hassan Mirmohammad Sadeghi: Conceptualization, Resources, Formal analysis. Majid Nemati: Conceptualization, Investigation. Ramin Ansari: Writing - Original Draft, Visualization. Shervin Shafiei: Writing - Review & Editing, Project administration.

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Data availability statement

The datasets generated during this study are available from the corresponding author upon reasonable request.

Conflicts of interest

The authors declare no potential conflict of interest with respect to the authorship and/or publication of this paper.

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