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RESEARCH ARTICLE

Non Vascularized Autogenous Bone Grafts for Immediate Reconstruction of Segmental Mandibular Defects: a systematic Review

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Abstract

This systematic review was performed to address the focus question " what is the various success rates, difficulties and complications of non vascularised bone grafts for **immediate** segmental mandibular reconstruction" ,in addition, this article reviews recent advances ,different techniques, and possible complications of autogenous non vascularised bone grafts for mandibular reconstruction that were previously discussed in the literature. A thorough Medline database search performed on related terms yielded **14016**. out of 398 abstracts selected, 124 full text articles were obtained for further evaluation. **Results** showed that a total of 18 studies followed the inclusion criteria. A primary analysis of the included studies showed that the majority were case series studies (11 articles) and only 3 Randomized controlled trials and 4 case reports were identified with most not providing objective and numerical outcomes of their results, Therefore quantitative data analysis and subsequent meta-analysis could not be performed. Results also showed variable success rates and complications of different immediate non vascularised autogenous graft forms. Many factors such as the size and site of the defect and the timing of reconstruction govern the success of the non vascularised bone grafts as an important option for immediate segmental mandibular reconstruction.

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Introduction

The rehabilitation of patients affected by defects of the mandible after tumor resection is still very challenging .first; it is difficult to replicate the complex three-dimensional conformation of the mandible. Second, Resection can lead to significant facial deformity, impaired oral functions such as speech, swallowing, saliva retention, and concomitant psychological problems. Moreover, the loss of teeth and the alveolar and basal jaw bone can lead to significant impairment of mastication.

There are different methods of reconstruction of such defects. Autogenous bone grafts are the most commonly used either vascularized free flaps or non-vascularized bone grafts; they have become a valuable means for the rehabilitation of these patients. Till now autogenous bone grafts is considered to be the **Gold Standard** and the most preferred method in reconstruction of such defects; this is because it allows the restoration of bone continuity and/or facial contour and also placement of dental implants in the reconstructed areas.The bony reconstruction is either performed simultaneously or in a second step after a period of oncological follow up. Timing of autogenous reconstruction is still a controversial topic throughout the literature that Till now a great point of debate (**Lawson et al., 1982, Foster et al 1999**).

The objective of the review was to identify and highlight the advantages and complications of simultaneous autogenous non vascularised bone grafts for restoration of mandibular segmental defects confirmed by the literature and to influence the selection of an ideal grafting technique based on clinically relevant recommendations that finally will affect patient quality of life.

Materials and methods:-

Focus Question

The focus question to be addressed was” what is the success rate and possible complications for non vascularised immediate autogenous bone grafting in segmental mandibular reconstruction”

Search strategy:

A search in the MEDLINE (Pubmed) database was performed on 10/June/2015 using the following search query:

- #1mandible OR mandibular (Mesh Terms)
- #2 Resection OR Defect OR Grafting OR Reconstruction
- #1AND #2

A hand search of journals was additionally performed to maximize capturing of all relevant publications **Table 1**. Reporting of this review is based upon PRISMA guidelines.

(Table 1)

Population	#1- mandible OR mandibular (Mesh Terms)
Intervention	#2 Resection OR Defect OR Grafting OR Reconstruction
Comparison	N.A
Outcome	4#- Success rates OR successful (Mesh Terms)
Search combination	#1AND # 2

Systematic Search Strategy

Database Search

Language	English
Electronic	Pubmed
Journals	Journal of Oral Maxillofacial Surgery , , Journal of Craniomaxillofacial Surgery, Journal of oral biology and craniofacial research, Journal of Clinical Oncology, plastic reconstructive surgery, british journal of oral and maxillofacial surgery, International journal of oral and maxillofacial implants.

Study selection:-

The result of this search yielded **14016** titles that were independently screened by two reviewers (M.A &M M.).

Out of the **14016** titles identified via pubmed and hand search ,The two reviewers agreed to exclude articles after screening titles and 398 articles were included to the second level of the search.

After subsequent screening, out of 398 articles 274 were excluded after screening abstracts and 106 were also excluded after subsequent screening of their full texts by the same reviewers.

At each level, any disagreements were discussed until a consensus was reached. Finally 18 full text articles were relevant to the inclusion and exclusion criteria of this review and also related to the answer of our PICO question formulated previously. **Figure 1**



Excluded studies : Table 2

After full text screening, the 106 articles were excluded from final analysis due to the following reasons:

- Review articles
- Languages other than English language
- Animal studies
- Grafts other than autogenous bone

(Table 2)
Selection criteria

Inclusion criteria	English language Human studies Mandibular segmental resection and reconstruction non vascularized bone graft.
Exclusion criteria	Languages other than English language Systematic reviews. Animal studies Non autogenous bone

Quality Assessment and Data Extraction (Table 3&4):

A Standardized descriptive table was used to record data for each article within the inclusion and exclusion criteria. Two reviewers evaluated the descriptive tables independently and any disagreement was resolved through open discussion.

(Table 3)
Studies included for Data Extraction

Type	Number	Studies
R.C.T.s	3	Lawson et al., 1982 , Kim & Donoff ., 1992 , Foster et al., 1999.
Case report	4	Montoro et al., 2008, Chen et al., 2004, Yoshimura et al., 2013, Ziang et al., 2013
Case series	11	Obwegeser and Sailer., 1978 , Simon et al., 2006, Shirani et al., 2007 , Chiapasco et al., 2008, Tosco et al., 2009, Boffano et al., 2011 , Zhou et al., 2010 , Ferri et al., 2013, Kim et al., 2013, Simon et al., 2013, Schlieve T et al., 2015.
Total	18	

(Table 4)
Critical appraisal :Risk of bias of randomized clinical trial according to Cochrane collaboration tool

Study	Adequate Sequence Generation?	Allocation Concealment?	Blinding of Participan?	Incomplete Outcome Data Addressed?	Free of selective Outcome Reporting?	Other Sources Of Bias?
Lawson et al	Yes	N.I	yes	N.I	yes	no
Kim and Donoff	Yes	No	N.I	yes	N.I	no
Foster et al	N.I	N.I	yes	N.I	N.I	no

N.I.....Not Identified

From the included articles the following data were extracted:

Table 5:

- Author
- Year
- Study design
- Number of patients
- Histopathology
- Site of the affected mandible

- Timing of grafting procedure
- Type of bone grafts
- Method of fixation
- Prosthetic rehabilitation
- Follow-up
- results

Statistical analysis:

A preliminary analysis of the included studies showed that the majority of studies were case series studies and only 3 randomized Clinical trials were identified. Most of the studies did not give a numerical value for their results. Therefore, quantitative data analysis and subsequent meta-analysis could not be performed.

Table 5
Data extracted from papers

Author	Year	Study design	No of patients	Mean age	Histo-pathology	Site	Timing	Type of bone Graft	Method of fixation	Prosthetic rehabilitation	Mean Follow up	Results
Lawson et al	1981	R.C.T	54	N.I	ORN SCC Odontogenic tumors	Symphysis Body Angle condyle	GP1: immediate GP2: delayed	Vascularized and non-vascularized iliac –rib-clavicle	Titanium mesh tra	Removable denture	6mths-5yrs	90% Success Rate with Delayed-46% success rate with delayed
Kim and Donoff	1992	R.C.T	41	52 ± 18.1	28 cases were malignant	GPA: ant. Mand GPB: body GPC: Ramus + condyle	29 pts (delayed) 12 pts (immediate)	Rib ,iliac, Coronoid grafts	AO reconstruction plate	No dental implants	N.I	17.2% revised of delayed reconstruction 33% was revised of immediate reconstruc
Foster et Al	1999	R.C.T	75	49	Trauma, ORN Benign Malignant	NI	IMMEDIATE For both groups	Vascularized (fibula) & non Vascularized Grafts	NI	Dental implants	NI	Graft union : 69%(NON VASC. BONE GRAFT) 96% in Vasc. Bone grafts

Author	year	Study design	No of pts	Mean age	Histo-pathology	Site	Timing	Type of bone graft	Method of fixation	Prosthetic rehabilitation	Follow up	Results
Montoro et al	2008	Case report	1	47	ameloblastoma	NI	immediate	Non Vascularised iliac crest	Mini plates Reconstruct Plates	Implant supported pros	8 months	Excellent graft consolodation
Chen et al	2010	Case report	1	14	Fibrous displasia	Symphesis , body , ramus, condyle	Immediate Reconst.	Non vascularized Double Costo-chondral graft	Reconstruction plates mini- plates	Removable Partial denture	3 yrs	Successful Immediate reconstruction
Yoshimura et Al	2013	Case report	1	35	Ossifying fibroma	Body, condyle	immediate	Non Vascularized iliac crest	Mini-plates	Dental implants	10 yrs	Successful, no recurrence
Ziang et al	2013	Case report	1	19	Aneurismal bone Cyst	condyle	immediate	Costo-chondral graft	Reconstru Ction plates	N.I	6 months	No evidence of Recurrence

Author	year	Study design	Num patie	Mean age	histopathology	site	timing	Type of bone Grafts	Method of fixation	Prosthetic rehabilitation	Follow up	Results
Obwegeser and Saller	1978	Case series	10	50	Ameloblastoma carcinomas	Body, rar condyle	immediate	Non vascularized Iliac crest, costochondral	Direct bone wiring	No implants	N.I	7 successful 3 failure
Simon et al	2006	Case series	11	27	ameloblastomas	Symphysis , angle	immediate	5 pts: autogenous particulate non vascularized bone graft + platelets rich	Two 2.4 plates	No prosthetic rehabilitation	N.I	7 pts showed uneventful wound healing & failure occurred in 4 pts

								plasma (PRP)				
Shirani et al	2007	Case series	7	13-46	Benign , Locally Aggressive lesions	Body ,ramus, condyle	immediate	Iliac crest block autogenous graft (non vascularized) + refixation of condylar process of the resected segment	Reconstruction plates	N.I	Up to 5 years	All the pts showed excellent graft consolidation & and uneventful wound healing
Chiapasco et al	2008	Case series	29	35.7	Benign lesions	N.I	immediate, delayed	,Non Vascularised iliac crest ,calvarial bone grafts	Reconstruction plates	16 pts received implant supported prosthesis	94 months	Successful graft concolidation in all pts except in 1 case that showed partial graft loss. Pts satisfaction was given a score.
Tosco et Al	2009	Case series	18	N.I	Central giant cell granuloma	12 cases Showed affected mandible maxilla	immediate	All pts (non vasc. Iliac crest),1 pt receive fibula free flap	Mini plates Reconstruction plates	Implants were placed	65 months	All grafts Survived, no lost implants
Boffano et al	2010	Case series	10	40.1	Odontogenic myxomas	8 of the pts affecting Mandible (body)	immediate	Non vascularised iliac crest	Reconstruction plates	N.I	67.3	Successful immediate grafts
Zhou et Al	2010	Case series	6	28.5	Benign tumors	Body ,ramus, condyle	immediate	Non Vascularised Iliac crest	3D prefabricated individual titanium prosth using Rreverse Engineering (RE) CAM technique	Dental Implants in 1 patient only	50 months	Woun healing was uneventful. Except In one pt who developed Infection and fistula formation
Ferri et Al	2012	CASE SERIES	2	Less Than 4 years	Desmoplastic fibromas	Hemi mandible	immediate	Rib grafts non vascularised	Mini plates	N.I	24-36 MONTH	Uneventful healing in 2 pts 1 pt need extra grafting Procedure
Kim et al	2013	Case series	3	19-23	Ameloblastoma Ossifying fibrom	Buccal bone resection	immediate	NOn Vascularised iliac crest	Mini plates	Dental Implant placement	3-8 years	Graft Consolidation, no Recurrence
Simon et Al	2013	Case series	32	27.6	ameloblastomas	Body , symphysis	immediate	Non vascular-Rised iliac crest + platlet rich plasma (prp)	2.4 plates	Removable partial Dentures for 13 pts only	6 months-7 years	Successful grafting procedures in 29 pts Recurrence in 1 pt & infection in 2 pts
Schlieve T, et al	2015	Case series	20	28.3	Benign pathology lesions	Body, symphysis	immediate	Non vascular anterior iliac crest	Reconstruction plate	Ten patients have undergone successful implant placement and restoration.	6 to 61 months	Ninety percent (18/20) of the subjects were successfully reconstructed

- N.I: not identified, ORN: Osteoradionecrosis

Results:-

The results of this search identified 18 full articles that were included in this systematic review of immediate non-vascular autogenous bone grafting procedures for mandibular segmental defects. Of these articles, 3 studies were randomized controlled trials, 4 case reports and the remaining 11 studies were case series (Table 3). Since no meta-analysis was possible the review of these studies will be descriptive in nature.

The literature contains a number of studies evaluating the success and various complications associated with non vascularised bone grafts for reconstruction of mandibular defects. According to this search, 18 publications were identified evaluating the use of these type of grafts. 3 randomized clinical trials, 4 case reports, and 11 case series. The most popular extra oral donor sites for non vascularised bone grafts are the iliac crest(either anterior or posterior) and the costochondral grafts that mainly used for reconstruction of disarticulation cases.

Discussion:-

Resection is an integral tool for the management of malignant and locally aggressive lesions causing massive destruction and disfigurement. Mandibular reconstruction can be performed immediately, at the time of the resection, or delayed. There are various immediate autogenous reconstructive options discussed in the literature, among which are non vascularized bone grafts (NVBGs) that are generally accepted treatment modalities for mandibular reconstruction.

Treatment of segmental mandibular defects is considered a complex process. Various techniques of reconstruction, ranging from simple bridging plates to composite free flaps have been adopted; each has its advantages and

disadvantages. Till now autogenous bone grafts is considered the Golden Standard and the most preferred method in reconstruction of such defects (**Yoshimura et al., 2013**).

Immediate or delayed bone grafting of the post-resection defect? This is still a controversial topic throughout the literature. In this study primary reconstruction was the treatment of choice in accordance to (**simon et al., 2006 and chiapasco et al., 2008**), based on its advantages over secondary reconstruction in terms of early resumption of function, reduction in the number of surgeries, overall cost, operation time, and hospital stay; as well as, better viability of recipient bed in terms of vascularity. On the other hand, presence of intra oral wound and possible salivary contamination of the graft are considerable disadvantages of the immediate reconstruction.

Benign tumors that allow soft tissue primary closure and do not need postsurgical radiotherapy remain the primary target for NVBG. In the current study NVBG from the iliac crest was chosen based on its numerous advantages well noted by (**kim & Donoff., 1992 and Schlieve T et al 2015**)

Many factors were discussed in the literature affecting the success rates of various non vascularized autogenous bone grafts for immediate segmental mandibular reconstruction. The most common factors are the type of the graft, timing of reconstruction, defect size & site (**Mounir et al., 2015**).

- **Types & forms of bone grafts:**

There are various forms and types of the autogenous bone grafts either non vascularised , pedicled or vascularised flaps, the most popular donor sites for the free non vascularised grafts are iliac crest (either anterior or posterior) and costochondral (rib grafts).

Several case series compared vascularised and non vascularised bone grafts for mandibular reconstruction. Although the nonvascular bone grafts decrease the overall operation time and hospital stay, vascular flaps have shown higher incidence of bony union, faster graft consolidation, fewer operations to achieve union, and minimal donor-site morbidity (**Mounir et al., 2015**).

The iliac crest as a non vascular donor site oppose several advantages that includes; large volume of harvestable bone (50 cc to 90 cc), possibility of a 2-team approach, naturally anatomically contoured for mandibular reconstructions, and minimal donor site morbidity if compared to vascularised bone grafts. Moreover, could be harvested in various forms such as block, particulate, cortical, or cortico- cancellous.

One of the main drawbacks of iliac NVBG is the graft volume loss. Several studies reported that Iliac graft have been associated with large degree of resorption this was attributed to its endochondral origin (**Zins & Whitaker., 1983**) and corticocancellous morphology. Another disadvantage of the iliac crest is the limited length when compared to the fibular graft (**Mounir et al., 2015 , Gadre., et al 2011**).

The costochondral grafts are considered to be a perfect option for reconstruction of mandibular condyles. This was attributed to its shape and cartilaginous nature that simulates the condyle of the mandible .its main drawback is that it had unpredictable growth pattern, easily resorbed and donor site morbidity. In the past, the mandibular condyles are considered a growth center that assisted in the growth of the mandible, recently and according to the functional matrix theory, it is considered to be a growth site that grow by the action of the surrounding musculature (**Zins & Whitaker., 1983**).

In a case report conducted by (**Chen et al., 2004**), for immediate reconstruction of a hemi mandibular defect including the condyle. They recommended the use of double non vascularised costochondral grafts, one for reconstruction of the inferior border and the other for alveolar process reconstruction.,the results were very promising in adolescents.

- **Timing of reconstruction (immediate versus delayed):**

(**Tidstrom KD & Keller EE., 1990**) have advocated secondary reconstruction of mandibular defects, especially those due to oncologic resection. They justified that secondary reconstruction allows early detection of recurrence of malignant disease. They also noted that the graft being placed after complete healing of the intraoral wound minimizes the chances of salivary contamination and allows for auto-sterilization of the graft bed, thus reducing the graft loss rate.

On the other hand, primary reconstruction following resection avoids segmental migration, which ensures maintenance of proper occlusion and facial form. It also prevents formation of excessive scar tissue in the defect area which makes secondary reconstruction more difficult. Moreover, it allows for early resumption of normal function.

(Markowitz et al., 1994) reporting on 14 patients reconstructed using vascular bone flaps, have emphasized the advantages of primary reconstruction and proved that, secondary reconstruction only improved aesthetics but not function. Although a higher complication rate was noted in the primary reconstruction group of patients, all complications were manageable and the flap loss rate was zero percent.

(Krüger & Krumholz., 1984) stated that the graft loss rate after immediate grafting procedures was much higher than that of the delayed. (Lawson & Biller., 1982) attributed the higher success rates of the delayed grafting to the salivary contamination due to the presence of intra oral wound. (Ardary., 1993) reported no difference between success rates of immediate and delayed grafting where both groups showed a graft incorporation rate of 100 %.

Site and size of the defect:-

Defect size is one of the necessitating factors in the choice of the reconstruction protocol. Vascularized choice was the common choice for most of the authors especially when it comes to segmental defects larger than 5Cm (Chiapasco et al., 2008). Moreover, vascularized free bone graft would be the preferred choice for reconstruction of irradiated large defects due to the hindered blood supply of defect site and the great possibility of non vascularized graft necrosis. On the other hand, several authors reported about successful application of non vascularized bone graft in reconstruction of large defects created by benign lesions under certain condition, which is the ability to attain a water tight closure at the intraoral side. This is totally dependent on the condition of the remaining mucosa after resection of the lesion (Lawson et al., 1982, and Yoshimura et al 2013).

Defect sites are divided mainly into two main categories unilateral and midline crossing defects. Majority of the complications occurs with reconstruction procedures crossing midline. One of the most serious complications is wound dehiscence with its probable subsequent graft failure, especially if the reconstruction procedure accomplished through intra oral approach due to contamination of the wound with the microbial intraoral flora. Defect crossing midline is at risk of wound dehiscence, this is attributed to loss of the insertion of the muscles of the tongue and the floor of the mouth (Van Gemert et al., 2009).

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