

VARIOUS TYPES OF BONE GRAFTING USED IN THE RECONSTRUCTION OF CLEFT MAXILLARY DEFECTS

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Abstract: *Over the past decades heterologous bone augmentation reached higher and higher limits due to the quality of materials used and the new technologies available to us. Even though, with the technological progression, autologous iliac crest augmentation of the alveolar clefts remained a golden standard in the reconstruction of these defects. Our study focuses on the quality and quantity of the stable bone left after the waiting period post augmentation, while at the same time comparing the two types of augmentation available. We have also introduced the Advanced Platelet Rich Fibrin a-PRF as a hastening factor in both types of augmentation from the moment it became available to us, and due to the positive results obtained we now consider a-PRF as mandatory if available.*

Key words: *bone grafting, autologous, regeneration, a-PRF.*

1. Introduction

Cleft maxilla (Fig 1.), specifically the alveolar bone grafting represents one of the last procedures necessary for the complete reconstruction of this congenital malformation, followed only by implanto-prosthetic procedure.

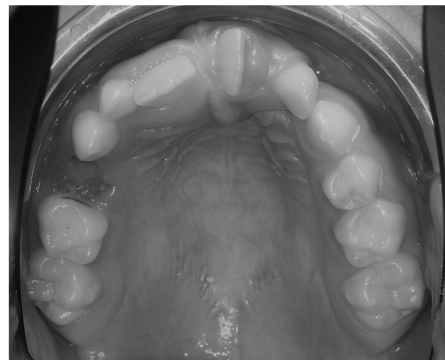


Fig. 1. Image of a cleft maxilla patient

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Various grafting materials have been used over the course of time, for the repair of the cleft defects starting in the early 1950s with autologous bone by Smidt - early grafting technique later abandoned due to the unfavourable outcomes [6]- and continuing to lyophilised bovine bone, but still returning to the initial procedures, but nowadays with far larger success due to the more strict asepsis and antisepsis rules.

Autologous bone grafting, specifically from the iliac crest, for cleft reconstruction surgery is considered to be the golden standard, because of the high amount of bone that can be harvested, the good management of complications that can arise in not one but two operative sites, but which, with good protocols have a very low incidence rate. Not only the bone harvested from the patients is of high quantity but generally also of high quality thus, making it the go-to donor site and type of intervention for cleft reconstruction surgery. However, even if complications rarely occur, they are present and if not managed correctly, they mean more harm than good.

Heterologous bone (bovine granulated or putty bone) is nowadays very accessible for almost every surgeon that wishes to take advantage of the osteoinductive and osteoconductive features that characterise this type of grafting material. Complications while using heterologous grafts are lower in number but higher in occurrence, dominated by the idiopathic resorption of the grafting material mainly due to maxillary growth and tension on to the sutures, or inappropriate blood supply from the periosteum [5].

Platelet Rich Plasma (PRP), Platelet Rich Fibrin (PRF) has been used for over a decade now as adjuvants in various

procedures including bone grafting, and especially oral implantology, providing extra blood supply when mostly needed at the proximal postoperative period but also, due to the different forms it can be prepared into, on the long term providing growth factors at the center of the grafting site [5], the patients is of high quantity but generally also of high quality thus, making it the go-to donor site and type of intervention for cleft reconstruction surgery. However, even if complications rarely occur, they are present and if not managed correctly, they mean more harm than good.

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2. Objectives

The objective of this paper is to make a comparison between two methods of

bone grafting, more specifically two types of bone grafting materials (autologous and heterologous bone compounds) in the reconstruction of cleft maxillary defects and additionally, to highlight the advantages that PRF techniques can offer.

3. Materials and Method

We have realised a study containing 28 patients ages 7-14 years with the main pathology being congenital alveolar clefts. We have separated the bone grafting periods, regarding age into three separate brackets as follows: 6-7 years we have considered to be early primary grafting, 8-10 years we have considered as early secondary grafting and 11-14 years was considered as normal grafting period. The reason behind making these categories is the speciality literature in accordance to Peterson Principles [7] and secondly due to the superior speed of osteointegration in the first two brackets in comparison to the last bracket [12].

We have used various types of grafting materials ranging from bovine lyophilised bone in the two states found on the market (granules and putty), as well as the addition of Advanced Platelet Rich Fibrin (a-PRF) as soon as it became available in our clinic (6 cases of heterologous bone grafts)

The amount of grafting materials used was relative to the palatal bone deficiency, primarily taking into consideration the facial growth pattern during the pre-surgical assessment of the patient [1]

Post-surgery quality of life was evaluated with the help of a questionnaire composed out of questions we deemed to be relevant, gathered from speciality literature [3].

4. Results

The normal bone loss 6 months after grafting is of 0.94mm \pm 0.1mm vertically and horizontally at the free part of the cleft, for patients augmented with heterologous grafts, and considerably smaller for autologous grafts (0.59mm \pm 0.1mm) (Table 1).

The addition of PRF into the heterologous bone grafts has registered a decrease in bone loss of 36.6%, registering a bone loss both horizontally and vertically of about 0.55mm \pm 0.1mm horizontally and 0.56mm \pm 0.1mm vertically, making the heterologous grafting method on-par with the golden standard, that is autologous grafts.

Quality of life was increased from a score of 3 before surgery to a score of 4 at 6 months after grafting for all patients regardless of the grafting method used, but a matter to be taken into consideration is that the two patients that finalised the treatment with dental implant and prosthetic crown this score has increased to almost perfect.

Quality of life questionnaire score has only suffered in the matter regarding the post-surgical scar present at lip-level for which dermatological hyaluronic acid and corticoid injections applied locally was instated.

Surgical sutures over the grafted area were sutured in a tension free fashion, using a suturing technique published by Choukroun et.a in 2010 (sutures made at approximately 6-7 mm away from the mucosal flap margins on both sides - vestibular and palatal, going over the grafted area then returning a second time-coronal wise) thus reducing the marginal margin flap tension even further, concluding in the final results that tension

related resorption for our patients was reduced to zero.

We encountered two cases of complete graft resorption which we omitted from the final conclusion: the first one we observed complete graft resorption of the autologous graft for which no reason could be established and we deemed it idiopathic bone resorption, and a second case in which the included canine had a traumatic effect on the graft. This final case was managed differently, with the extraction of the included canine and re-grafting of the site.

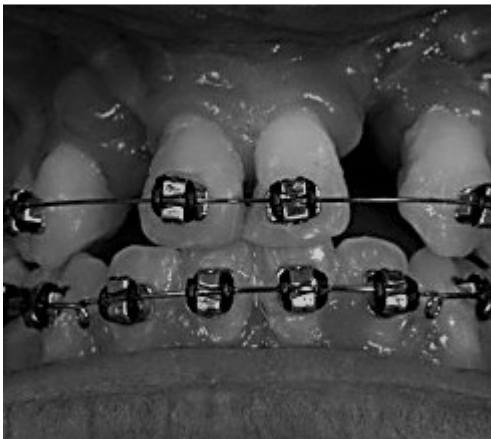


Fig. 2. *Image of pre-surgical orthodontic treatment for patient with bilateral cleft maxilla*

Pre-surgical and postsurgical analysis was made using 3D-reconstruction Cone Beam Computer Tomography (CBCT). The software allows us to accurately measure the exact amount of bone present as well as the amount of bone lost in mm in all dimensions in millimetres with two decimals.

As grafting materials, we used the following: cancellous bone harvested from the patients iliac spine during surgery for 17 cases (autologous), putty lyophilised bovine bone in 5 cases, granule

5. Discussion

Orthodontic treatment is the first step to take when starting a treatment plan for the reconstruction of cleft maxilla defects. It is recommended that orthodontic treatment is started 8-12 months before surgery in order to correct maxillary growth deficiencies, to align the two segments of maxilla and place them into the final correct position (occlusion and aesthetic-wise) (Figures 2 and 3).

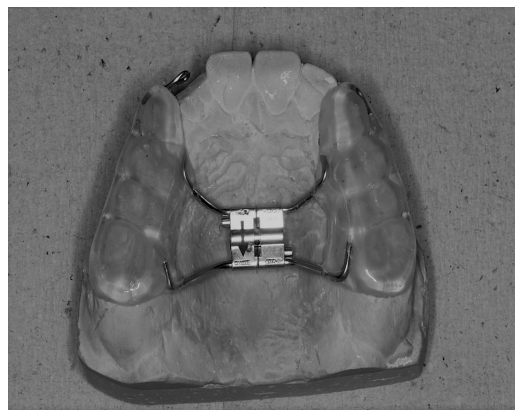


Fig. 3. *Image of Maxillary expander used in orthodontic treatment*

lyophilised bovine bone for 6 cases. We mention that one of the 17 cases of autologous grafts was completed by a small amount of putty bone since the amount harvested from the iliac crest was insufficient.

Autologous bone was harvested by using a window technique from the iliac crest using rotative or piezotome tools, on the medial side of the crest, always harvesting just enough grafting material needed for each case after calculations made on CBCT

3d evaluation, which allows for a faster healing of the donor site [2], [8].

Donor site was cared for, for the first 5 days after harvesting, with daily antiseptical dressings and also any signs of infection or cutaneous femoral nerve affliction [7].

Our research has shown that the graft bone loss was the smallest for autologous bone followed by putty lyophilised bone and then granule bovine bone in the last place with most of the bone lost at 6 months after grafting.

If bone loss could be predicted stepping out of the expected target areas, grafting with autologous bone was done in excess.

In addition to the osseous grafting materials we also added a-PRF to the grafting sites as soon as it became available in our clinic (6 cases), with the help of the Chouckroun a-PRF Centrifuge. Also, for the last two patients the protocol was changed with the added i-PRF injection into the mucosa proximal to the clefts site.

The addition of a-PRF for heterologous bone has decreased the amount of bone lost after grafting by more than 30% at 6 months after grafting. This is not only a small improvement but of paramount importance to the final aspect and maxillary development (Table 1).

Table 1

Types of augmentation and bone loss at 6 months post surgery

No.	Lyophilised Granule	Lyophilised Putty	Autologous Cancellous	A-PRF	Bone Resorbtion at 6 months
1	Yes			Yes	0.5mm horiz/0.57mm vert
2	Yes			Yes	0.45mm horiz/0.48mm vert
3	Yes			Yes	0.69mm horiz/0.60mm vert
4	Yes				1.1mm horiz/0.9mm vert
5	Yes				0.95mm horiz/0.88mm vert
6	Yes				1mm horiz/0.95mm vert
7		Yes		Yes	0.51mm horiz/0.55mm vert
8		Yes		Yes	0.58mm horiz/0.6 mm vert
9		Yes		Yes	0.6mm horiz/0.6mm vert
10		Yes			0.88mm horiz/0.85mm vert
11		Yes			0.8mm horiz/0.91mm vert
12			Yes		0.65mm horiz/0.7mm vert
13			Yes		0.52mm horiz/0.6mm vert
14			Yes		0.60mm horiz/0.65mm vert
15			Yes		0.64mm horiz/0.7mm vert
16			Yes		0.59mm horiz/ 0.62mm vert
17			Yes		0.75mm horiz/ 0.8mm vert
18			Yes		0.62mm horiz/0.69mm vert
19			Yes		0.57mm horiz/0.61mm vert
20			Yes		0.6mm horiz/ 0.6mm vert
21			Yes		0.55mm horiz/0.6mm vert
22			Yes		0.6mm horiz/ 0.7mm vert
23			Yes		0.62mm horiz/0.64mm vert
24			Yes		0.5mm horiz/0.55mm vert

No.	Lyophilised Granule	Lyophilised Putty	Autologous Cancellous	A-PRF	Bone Resorbtion at 6 months
25			Yes		0.2mm horiz/0.6mm vert
26			Yes		Idiopathic bone grafts complete resorbtion
27		Yes	Yes		
28			Yes		Complete resorbtion (canine inclusion)

4-8 vacutainers x10ml of venous blood were taken from the patients in order to prepare both Injectable Platelet Rich Fibrin (i-PRF) and Advanced Platelet Rich Fibrin(a-PRF) in sufficient quantity, thus assuring a higher success rate.

Preparation of the a-PRF was done by following standard centrifugation protocol: 1300 rpm for 8 minutes, followed by the extraction of the condensed plasma from the vacutainer, compression using the special manipulation tools, thus shaping the a-PRF into a small membrane that can be predictably added to the cleft site after the bone graft.

Injectable Platelet Rich Fibrin (I-PRF) protocol is lightly different, as follows: 700 rpm for 3 minutes, for 2-3 vacutainers of blood, assuring enough quantity for pre-surgical injection

The addition of i-PRF and a-PRF has been included into the autologous grafting protocol but data has not yet been gathered in order to display relevant results.

New methods of preparing a-PRF have now arisen from the developers (nr Chouckroun et.a), -preparation of a PRF-bone block with the possibility of moulding it to the exact shape needed.

We have recently started using a-PRF/heterologous bone concept grafting material prepared in our clinic with splendid results so far, logging close to no bone loss at 6 months after surgery.

The protocol developed in our clinic requires mandatory pre-surgical orthodontic treatment, if maxillary growth of the smaller segment of the cleft is not on-par with the growth of the larger part of the maxillary. Pre-surgical orthodontic treatment also ensures predictability and better surgical stage planning.

All flaps were then sutured over the grafting material in a tension-free matter to reduce stress on the newly added bone thus increasing the change of success and decreasing the chance of bone resorbtion [4]. Grafting in excess causes extra tension on the grafting material by the mucosa and periosteum inducing bone resorbtion. We do not recommend periosteum incision in order to mobilise the flap coronal but rather a sharp dissection between the mucosa and the periosteum thus gaining flap flexibility and elasticity while not compromising the bone vascularisation.

Even though the water-tight closure of the maxillary is the main target for the reconstruction of the cleft maxillary defects, the proper quality of life post-surgically is the ultimate concern. Evaluation of the quality of life was made through a small questionnaire composed out of 8 questions that mainly focus on liquid reflux, breathing, eating, aesthetic aspect but also return to society.

Aesthetic and return to society aspects can more easily be achieved by the use of nasoalveolar moulding (NAM) procedures

as the main infant pre-surgical orthopaedic treatment that ultimately require less aggressive orthodontic treatment but also less amount of grafting material.[9][10] Unfortunately, since not uniformly enforced, and due to late patient presentation, NAM procedures are not properly applied leading to an increase in difficulty of the reconstruction.

6. Conclusions

Autologous grafting with bone harvested from the iliac crest still remains in our opinion the golden standard for the reconstruction of the cleft maxillary defects, even if the complications do exist they are far less frequent consisting majorly out of manageable low levels of pain at the donor site, if the harvesting procedure was done according to protocols.

Even though results obtained with autologous and heterologous grafting techniques while using a-PRF in the latter were similar, the costs of the seconds technique are a deal-breaker for now.

While still a good option for grafting, heterologous bovine lyophilised bone, due to its higher costs and higher resorption rate falls into second place to the autologous grafts.

Heterologous bone is the go-to grafting option if iliac crest autologous grafting is not possible due to a low amount of grafting material that can be obtained or the foreseeable complications that can occur during and after harvesting.

A-PRF increases the chance of success of the graft by a good amount, therefore we now consider it as being a mandatory step in the reconstruction of the cleft maxillary defects.[11]

A-PRF is not only an accessible technique, it is also cost effective and highly beneficial for the final result of the reconstruction.

Orthodontic treatment done before surgery offers predictability in both grafting options and final results.

Suturing in a tension free manner is only an easy step if during the cleft lip repair the terrain has been prepared, by leaving an excess of mucosa on the mucosal side of the lip.

Managing the cleft defect in the anterior part of the maxilla, is in our opinion mandatory and should be enforced, for greatly increasing the quality of life of the patients.

Even with the application to the word of the grafting protocol, the target success line cannot be reached without proper orthodontic treatment beforehand.

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