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CONTENTS

SCINTIGRAPHIC ASSESSMENT OF CRANIOFACIAL BONE TRANSPLANTS: EXPERIMENTAL STUDY IN RABBITS[1]

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We aimed at evaluating the behavior of intramembranous bone used for allografts in the facial region. Ninety adult, female, non-isogenous New Zealand rabbits were used. Thirty animals were donors of 60 zygomatic arch bone segments, used as allografts. Sixty animals were distributed into three groups: Autogenous group (30 animals), submitted to transplantation of a right zygomatic arch segment to the area of a surgically created bone defect on the left arch; Fresh allogenous group (15 animals), which received two segments from the same donor to an area of surgically created bone defect on both arches; frozen allogenous group (15 animals), in which bone segments from the same donor were frozen and submitted to irradiation before being transferred to the recipients. For scintigraphic assessment, anesthetized animals received 5 mCi (185 MBq) ^{99m}Tc-MDP, and were kept under observation for 2 hours. After that, rabbits were sacrificed and their heads were scintigraphically examined. Groups were subdivided into lots for post-surgical evaluation, which was performed after 2, 6, and 16 weeks. Three reference areas were defined, projecting from the right and the left zygomatic arch regions (8 x 10 pixels). Another area was defined over the nasal bone (24 x 25 pixels). A scintigraphic index was defined to allow the comparative analysis of data. Scintigraphic assessment revealed that the scintigraphic index was highest after 2 weeks, and lowest after 16 weeks. Behavior of frozen allogenous and autogenous group indices was similar, suggesting that frozen allografts present osteoblastic activity, which would justify their clinical use.

***KEY WORDS:** Bone transplant, bone bank, zygomatic arch, New Zealand rabbits.*

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Bone transplantation is a therapeutic method that is widely used in orthopedics and in craniomaxillofacial surgery with the aim of reconstructing areas where loss of bone has occurred or of correcting congenital malformations. Fresh autogenous bone transplants are considered as the best material for this purpose, and can be obtained from appropriate donor areas (1-4). However, in situations of extensive loss, bone removal will cause serious lesions to the donor area, rendering the procedure unfeasible or highly morbid. Thus, the use of allogenic bone from bone banks is indicated; nowadays, this technique is commonly employed and accepted worldwide (5-10).

Bone in banks can be lyophilized, demineralized, or kept at low temperatures. Lyophilization requires complex and expensive processing of the material, and it is available only at centers which have adequate financial and technological resources. Demineralized or decalcified bone presents high osteoinductive capabilities; however, due to its malleability, the mechanical resistance of decalcified bone is not always appropriate for certain recipient sites. Bone stored at low temperatures is less osteoinductive than demineralized bone, but its preparation is inexpensive and relatively simple.

The Orthopedics and Traumatology Department at Universidade Federal de São Paulo, Escola Paulista de Medicina (UNIFESP-EPM), has 10 years of clinical experience with bone banking. We have achieved good results in the skeletal reconstruction of patients submitted to surgical ablation of osseous tumors (9,11).

Based on our clinical experience and on experiments previously carried out (12,13), and taking advantage of an existing protocol, we conceived the establishment of a "craniofacial bone bank," which would extend the therapeutic resources of bone banking to more serious cases of bone loss of the cranial skeleton. The experiment described in the present paper aimed at evaluating the behavior of intramembranous bone used for allografts in the facial region. We also took the opportunity to become familiarized with the surgical technique.

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MATERIALS AND METHODS

Ninety adult, female, non-isogenous New Zealand albino rabbits were used. Thirty animals were donors of 60 zygomatic arch bone segments. These segments were used as allografts. The remaining 60 animals were distributed into the following groups:

I - Autogenous group (30 animals): Each animal was submitted to transplantation of a bone segment from the right zygomatic arch to the area of a surgically created bone defect on the left zygomatic arch.

II - Fresh allogenous group (15 animals): Each animal received two bone segments from the same donor. The segments were transferred to an area of surgically created bone defect on both zygomatic arches.

III - Frozen allogenous group (15 animals): As with the previous group, each animal received two bone segments from the same donor. In this group, however, the segments were frozen and submitted to irradiation before they were transferred to the recipients.

Preparation of bone for banking

The bone fragments of 15 donors, intended for the frozen allogenous group, were submitted to a single irradiation session of telecobalt therapy (ALCIAN II - GE). The fragments received one single 25 Gy dose. They were stored in sterilized containers and kept in a special freezer at −70°C for a minimum period of 1 week. The fragments were subsequently transplanted into the recipients.

Prior to the transplantation procedure, the bone fragments were immersed in cephalothin solution (2mg/ml) for 6 hours. Prior to and after the immersion in the antibiotic solution, we collected samples from each fragment for a bacteriological exam.

Preparation of the animals

Animals were anesthetized with 35 mg/kg ketamine hydrochloride, associated with 0.75 mg/kg acepromazine as pre-anesthetic therapy. Following antisepsis, the anesthesia was augmented by local infiltration of lidocaine solution at 0.2%, with addition of adrenaline for a concentration of 1:200,000, always observing the maximum dosage of lidocaine (7mg/kg).

Surgical technique

The zygomatic arches were reached through the same path in both donor and recipient rabbits. A cutaneous incision was made at the infra orbital region, 6mm from the inferior ciliary line. Once we located the zygomatic arch, it was exposed by subperiosteal dissection. At the end of the procedure, all recipients received an intramuscular injection of 50,000 IU/kg benzathine penicillin.

For the autogenous group, we performed a 15 mm segmental bone resection on the right zygomatic arch. On the left zygomatic arch, we created a 5 mm segmental bone defect. The extremities of the right zygomatic arch bone fragment were drilled, and then placed as a "bridge" over the left zygomatic arch, so that the defect area was covered. The fragment was attached with 4mm x 1mm titanium screws by lag screw compression (figure 1).

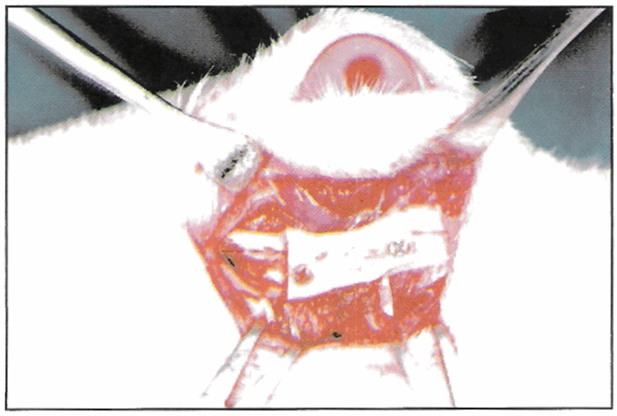

Figure 1. Transplant with rigid "bridge" fixation over the recipient zone.

In the fresh allogenous group, each animal received two bone segments from the same donor, immediately after collection. The segments were attached in the same manner described for the left zygomatic arch of the autogenous group. However, they were transferred to both zygomatic arches, and placed contralaterally to their original position in the donor rabbit.

For animals in the frozen allogenous group, after immersion in antibiotic solution, the bone segments stored in "bone banks" were transferred to the recipient rabbits using a procedure identical to that of the fresh allogenous group.

Figure 2 illustrates the procedures that were carried out for each of the three groups.

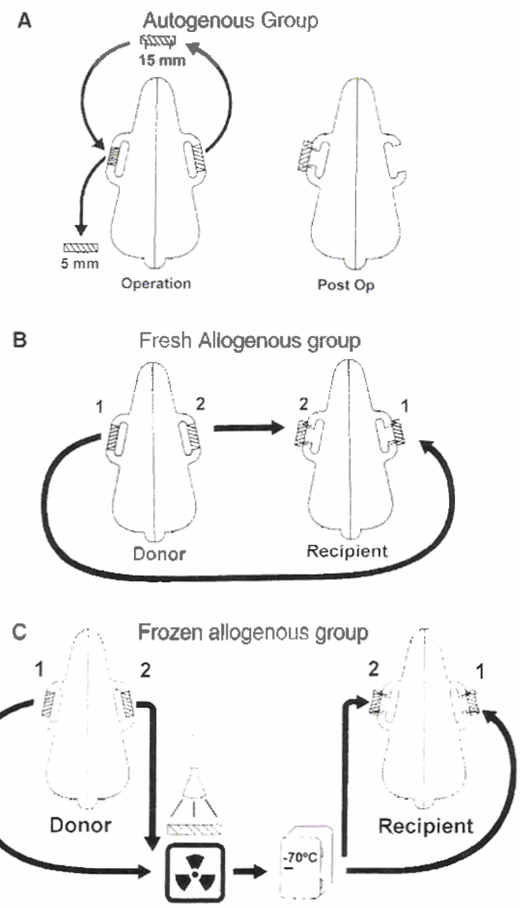

Figure 2. Transplants carried out in A) autogenous group; B) fresh allogenous group; C) frozen allogenous group.

Groups were equally subdivided into lots for post-surgical evaluation of the animals, which was performed 2, 6, and 16 weeks after surgery.

Scintigraphic assessment method

Each animal received 5 mCi (185 MBq) ^{99m}Tc-MDP. All the rabbits were anesthetized prior to administration of the radiopharmaceutical agent, and were kept under observation for 2 hours following the injection. After the observation period, the rabbits were sacrificed and their heads were immediately sent to be scintigraphically examined. Scintigraphy was carried out in a gamma-chamber (model APEX SP4HR), with a low-energy, general-purpose parallel hole collimator. Spectrometry was centered at the ^{99m}Tc energy peak of 140 KeV, with a 10% window. We acquired static images of 100 K, with a 256 x 256 pixel matrix.

We defined three areas of interest for each animal, projecting from the right and the left zygomatic arch regions, each measuring 8 x 10 pixels. Also, a reference area was projected over the nasal bone, measuring 24 x 25 pixels (figure 3).

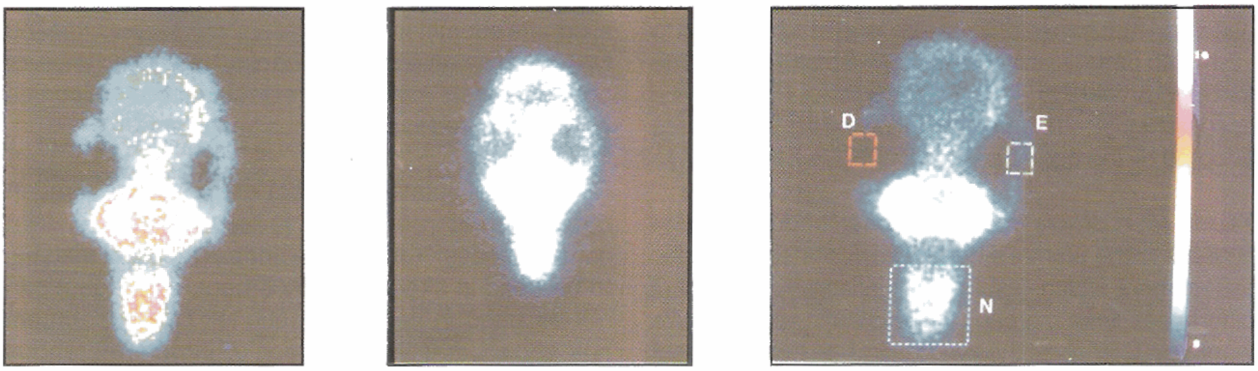

Figure 3. Scintigraphy in animals from the 16-week lots. A) Autogenous group; B) fresh allogenous group; C) areas of interest. D) Right zygomatic arch; E) left zygomatic arch; N) nasal region.

Scintigraphic Index

A scintigraphic index was defined in order to allow the comparative analysis of data obtained through the scintigraphic examination of animals in the same group, animals in different groups, and of data from the various assessment periods, according to the formula below:

$$I_D = \frac{\text{right zygomatic arch uptake}}{\text{nasal area uptake}} \times 100$$

$$I_E = \frac{\text{left zygomatic arch uptake}}{\text{nasal area uptake}} \times 100$$

I_D represents the scintigraphic index for the right side and I_E represents the scintigraphic index for the left side.

RESULTS

Bacteriological examination

After soaking stored bone fragments in antibiotic solution, bacteriological cultures were negative for microorganisms.

Scintigraphic indices

Scintigraphic index averages for assessed animals are presented below, according to transplant group and period of post-surgical evaluation (table I).

Table 1. Scintigraphic index average for the autogenous, fresh allogenous and frozen allogenous groups, according to post-surgical periods of 2, 6 and 16 weeks

Period (weeks)	Autogenous group	Fresh allogenous group	Frozen allogenous group
2	7.41	7.84	6.40
6	6.71	5.68	5.30
16	5.22	3.12	4.86

DISCUSSION

Many studies have demonstrated the superiority of intramembranous bone (most of the cranial bones are of intramembranous origin) for purposes of transplantation to the cephalic skeleton (4, 12, 14-17). Among all the cranial bones, the outer table of the skull is ideal for bone transplants into the craniofacial skeleton, because its removal is easy and does not cause any serious deformities to the donor area (1, 12, 18). By selecting the zygomatic arch for this experimental study, we were able to work with intramembranous bone (17, 19). This also allowed us to use rigid skeletal fixation with screws, a technique that has better results than non-rigid fixation (12, 15, 16).

Friedlander (20) has noted that fresh allografts are highly antigenic, whereas bone submitted to intense cold, similarly to lyophilized bone, has low antigenicity. *In vitro* studies have demonstrated that frozen allogenous bone is associated to low levels of humoral antibodies in various types of animals. Marques (21), however, was not able to demonstrate an antigenic reaction to fresh allografts in a study with laboratory animals.

Parrish (6, 22) reported good clinical results with allogenous bone stored at –20°C, while Stefani (8) had good results with bone stored at –18°C. Malinin (10) observed that transplants can be kept at –20°C for 3 to 12-month periods, and that it is possible to store bone for up to 5 years at –70° to –80°C. In our project, we used a special –70°C freezer, following the procedures adopted by the bone bank at UNIFESP–EPM (9, 11).

The fixation of the transplant as a "bridge," placed laterally to the animal's head, allowed a scintigraphic assessment which resulted in statistically significant differences among groups and evaluation periods. We were able to analyze the zygomatic arch region without interference from other bony areas of the head. Therefore, our results were different from those obtained by Almeida et al. (13), who did not observe a significant difference in the scintigraphic assessment of bone transplants placed on the nasal dorsum of rabbits. Those authors determined a scintigraphic metabolic index by measuring the areas of interest in each animal studied and subtracting the background radiation. In our experiment, the scintigraphic index is defined as the scintigraphic count of the region under study, divided by the capture of a standard area (not submitted to surgery) located in the nasal bone region. These results were then multiplied by 100 for percentage assessment of the values obtained. The objective of this procedure was to correct any possible distortions in terms of body distribution, or in terms of the time gap between administration of the radiopharmaceutical agent and scintigraphic measurement.

The scintigraphic assessment revealed that, within each group, the count decreased progressively with time; that is, the scintigraphic index was highest after 2 weeks, and was lowest after 16 weeks. These indices suggest that osteoblastic activity, with which MDP has greater affinity (23), also decreases with time, and tends towards rest as soon as physiological integration ends. Marks (24) pointed out that it is possible to find areas of activity and areas of rest in the same bone. However, inactive areas maintain their potential for reacting to certain specific stimuli and for initiating new cycles of absorption-neoformation.

During the initial phase, the fresh allogenous group behaved as the most active one, though it presented the lowest indices during late phases. This might be explained as a trend towards reaching inactivity in less time, or as the result of reduced osteoinduction capability, perhaps because this capability is blocked or minimized by rejection phenomena. The frozen allogenous group and the autogenous group behaved similarly, but had lower scintigraphic indices than the fresh allogenous group. These data allow us to infer that allografts are indeed capable of osteoinduction, although their capability is inferior to that of autogenous transplants.

The gradual decrease in the frozen allogenous group indices, unlike the late and abrupt decrease of the fresh allogenous group indices, suggests a physiological phenomenon, and not rejection-related blocking. Frozen allografts submitted to irradiation, which constitute the type of transplant from bone banks, have less, however not completely ineffective, osteoinductive properties when compared to autogenous transplants.

Currently, alloplastic (acrylic) materials are used in most cranial reconstructions, with well known consequences. Autogenous bone is the ideal material to be used in skeletal replacement, although it can not be used in certain situations. This experiment has shown that the behavior of intramembranous allogenous bone is similar to the behavior of endochondral bone, referred in the literature. Thus, before bone substitutes are available for clinical use, bone banks will remain important for research and therapy, in order to stimulate the development of bone substitutes and to provide opportunities for development and practice of transplant techniques.

The superiority of intramembranous bone transplants, the possibility of working with isotopic bone, which is more adaptable to the recipient site, and the organ bank protocols that are already established, especially bone bank protocols, give support to the idea of a craniofacial bone bank. The experience of the bone bank at UNIFESP-EPM, which is fully operational and which has established protocols for the procurement, selection and exclusion of allogenous bone, makes this a feasible project, which would offer additional therapeutic resources for the treatment of serious deformities of the craniofacial skeleton.

CONCLUSIONS

1. The process used for procurement, storage and transplant of allografts allowed us to work with sterile bone.
2. A scintigraphic evaluation was made possible by the "bridge" fixation of bone transplants over the zygomatic region in rabbits. We were able to observe statistically significant differences among the groups and assessment periods.
3. Scintigraphic indices decreased with time for the three groups studied.
4. The behavior of the frozen allogenous group indices was similar to the behavior of the autogenous group indices. This suggests that frozen allografts do present osteoblastic activity, which would justify their clinical use.

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FACIAL GROWTH IN MANDIBLE ELONGATION AND HEMIFACIAL MICROSOMIA

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Distraction osteogenesis is one of the options for treatment of hemifacial microsomia. The objective of the present study was to compare the results of this technique in terms of facial growth in two different age groups. Two groups of four hemifacial microsomia patients (degree II according to Pruzanski criteria) were treated between 18 and 24 months of age (Group I) and between 7 and 9 years of age (Group II). Pre and postoperative pictures taken from the patients were analyzed and cephalometry was performed to evaluate the mandible and facial elongation of the patients in each group. Measurements were subsequently compared. In visual terms, patients in Group I had more harmonic results than patients in Group II. In terms of lateral mandible elongation, Group I reached normal measures, while Group II patients had an important growth, with better symmetry, but did not reach normal measures. In terms of frontal facial growth, Group I showed improvement in facial symmetry. Group II showed improved symmetry in relation to the points measured. The performance of mandibular elongation for treatment of hemifacial microsomia at an earlier age (18 to 24 months of age) can avoid the problems resulting from secondary facial growth in the maxilla and orbit caused by mandible hypoplasia of the mandibular ramus and ascendent angle.

KEY WORDS: *Mandible elongation, facial growth, hemifacial microsomia.*

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Hemifacial microsomia is a congenital disease that affects the structures derived from the first and second branchial arches. Its most important clinical characteristics are microtia and facial asymmetry produced by mandibular hypoplasia associated to masticatory muscle hypoplasia in the parotid gland, in some cases with local facial palsy. Since the development of craniofacial surgery, several surgical techniques have been employed for treatment of hemifacial microsomia, such as complete osteotomies, bone grafts, as well as microsurgical procedures. Initially, all these produce satisfactory results; however, there is a large percentage of long-term loss (1-9). Initially described by Ilizarov in 1954 (10, 11), the procedure of distraction osteogenesis was first applied experimentally in the mandible in 1973, in a study by Snyder (12). The usefulness of this treatment was clinically confirmed by Mac Carthy in 1992 (5). In the last years, mandibular distraction osteogenesis has become an important reconstructive technique, producing excellent results for the treatment of hemifacial microsomia (6).

Mandibular hypoplasia can affect the gonial angle (grade I), the angle and the ascending ramus (grade IIA and IIB) or the absence of the ramus and the condyle (grade III) (4,7,13). Distraction osteogenesis can promote bone lengthening and remodeling, simultaneously producing functional alterations that are very significant to the temporomandibular articulations, such as tridimensional expansion of soft-tissues of the affected hemiface (6, 14).

The objective of this work was to check if there are differences between performing distraction osteogenesis at an earlier age or at a later age. For that, we present an analysis of facial growth in two groups of patients with hemifacial microsomia, 3 years and 6 months after the treatment with mandibular elongation.

MATERIALS AND METHODS

We selected patients with hemifacial microsomia treated by distraction osteogenesis at different ages. They were divided into two groups according to the age in which they had received the treatment. Group I included four patients with degree IIA hemifacial microsomia, treated between 18 and 24 months of age, with unidirectional, unilateral, mandibular lengthening.

Group II included four patients with degree IIA hemifacial microsomia, treated between 7 and 9 years of age, with unidirectional, unilateral, mandibular lengthening. For all patients, we analyzed a) preoperative clinical photographs taken during the distraction procedure; b) photographs taken at the end of the consolidation period; and c) photographs taken 3 years and 6 months later. For evaluation of mandibular and facial elongation, measurements were performed between cephalometric points defined according to Ricketts' cephalometric relationships.

Mandible growth

To evaluate mandibular growth, we performed measurements of the lateral face cephalometric X-rays, pre-distraction and 3 years and 6 months after the process of mandibular elongation, using the following

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points: condylo-pogonion (Co-Po), condylo-menton (Co-Me) and condylo-gonion (Co-Go). Measures were expressed in millimeters and compared percentually with the normal values for the age of the patient.

Facial growth

To evaluate the facial growth, including growth of the mandible and the maxilla, we performed measurements in the frontal cephalometric radiographs, pre-distraction and 3 years and 6 months after the procedure of mandibular elongation. Measurements between the following points were obtained using Ricketts' cephalometric analysis: zygomatic in orbit projection (Zo); mandibular lengthening (Zl); orbital (O), jugal (J) and gonion (G). Measures were express in millimeters and compared percentually with the contralateral measurements of the patient.

RESULTS

In each group of patients, the most demonstrative X-rays were chosen.

Mandible growth (lateral)

In Group I , prior to the analysis of mandibular growth, a normalization of all measurements was performed (table 1). As for Group II, we observed that mandible measures became close to the normal values of growth. We obtained measures that varied from 17.5% to 0.4% in relation to normal values (table 2).

Table 1. Mandibular growth in Group I

Points measured	Pre-distraction (mm)	Post-distraction (mm)	Normal values (mm)
Condylo-Pogonion	81	95	94.6 – 98.9
Condylo-Menton	81	94	93.7 – 97.6
Condylo-Gonion	35	46	43.6 – 46.5

Table 2. Mandible growth in Group II

			Normal values		%	
Points measured (mm)	Pre-distraction (mm)	Post-distraction (mm)	Pre-distraction	Post-distraction	Pre-distraction	Post-distraction
Condylo-Pogonion	92	109	105.9	113.6	86.9	95.9
Condylo-Menton	93	111	104.1	111.4	89.3	99.6
Condylo-Gonion	38	44	49.5	53.3	76.7	82.5

Mandible growth (frontal)

For facial growth we used measurements that allowed us to observe greater facial growth in the affected side in comparison with the normal side in all cases. In the younger group, facial growth of the affected side was smaller than growth of the affected side in the older group. Younger patients presented better facial symmetry; we were able to go from a 22.7% difference to a 0% (as in the evaluated segment) difference in comparison with the normal growth contralateral side (tables 3 and 4). In relation to Group II, measurements showed a large facial growth in the affected side after the distraction process, with measures having a 34.8% to 0% difference in relation to the affected side (tables 5 and 6).

Table 3. Maxillofacial A.P. growth: Group I

		Pre-distraction(mm)		Post-distraction(mm)		% Growth	
Points measured		Hemifacial microsomia affected	Normal	Hemifacial microsomia affected	Normal	Hemifacial microsomia affected	Normal
Zo	G	47	49	57	59	21.3	20.4
Zl	G	42	46	46	47	9.5	2.1
J	G	28	30	22	27	-21.4	-10.0
O	J	13	16	30	30	130.1	87.5
O	G	40	46	52	56	30.0	21.7
Zo	J	47	48	57	57	21.3	18.7

Table 4. Contralateral comparative growth in Group I

Points measured (mm)		Difference pre-distraction Affected/Normal (mm)	%	Difference post-distraction Affected/Normal (mm)	%	Difference (%)
Zo	G	02	4.2	02	3.5	-00.7
ZI	G	04	9.5	01	2.2	-07.3
J	G	02	7.1	05	22.7	+15.6
O	J	03	23.1	Zero	—	-23.1
O	G	06	15.0	04	7.7	-07.8
Zo	J	01	2.1	Zero	—	-02.1

Table 5. Maxillofacial A.P. Growth: Group II

		Pre-distraction(mm)		Post-distraction(mm)		% Growth	
Points measured		Hemifacial microsomia affected	Normal	Hemifacial microsomia affected	Normal	Hemifacial microsomia affected	Normal
Zo	G	77	90	84	94	9.1	4.4
ZI	G	44	59	54	67	22.7	13.5
J	G	26	32	23	31	-11.5	-3.1
O	J	21	31	31	31	47.6	—
O	G	47	63	53	64	12.8	1.6
Zo	J	52	62	64	64	23.1	3.2

Table 6. Contralateral comparative growth in Group II

Points measured (mm)		Difference pre-distraction Affected/Normal (mm)	%	Difference post-distraction Affected/Normal (mm)	%	Difference (%)
Zo	G	13	16.9	10	11.9	-0.50
ZI	G	15	34.1	13	24.1	-10.0
J	G	06	23.1	08	34.8	+11.7
O	J	10	47.6	zero	—	-47.6
O	G	16	34.0	11	20.7	-13.3
Zo	J	10	19.2	zero	—	-19.2

Aesthetic results

The initial pre-distraction photos showed a worse asymmetry in Group II. Group I presented better final aesthetic results after a long follow-up. Figure 1 shows a patient from Group I immediately after distraction and after 3 years. Figure 2 shows a patient from Group II before distraction and 3 years and 6 months after distraction.

Figure 1. Group I patient, immediately after the distraction procedure and after 3 years and 6 months.

Figure 2. Group II patient, immediately after the distraction procedure and after 3 years and 6 months.

DISCUSSION

Mandibular elongation and remodeling by corticotomies and bone lengthening appears to be a simple procedure with minimal morbidity and complications. Besides elongation, this procedure enables lengthening of soft-tissues, such as skin, muscles, vases and nerves (6). The age in which the distraction procedure is usually carried out varies from 2 to 17 years, but the majority of the patients are between 4 and 6 years of age.

In our study, evaluation of the results was carried out after a long interval, 3 years and 6 months, since the objective of the treatment is to provide not just an immediate growth of the affected hemiface, but rather to promote facial development within normal patterns. Three years and 6 months after the distraction procedure in Group I, mandible growth (lateral) measures were within normal patterns of growth.

In Group II patients, submitted to treatment at an older age, there was an improvement in the measures in relation to the pattern of normal facial growth, but they did not reach normality; therefore, these patients will eventually have to be submitted to a new distraction procedure. The prediction of màndibular growth can be done by superimposing images, as shown by Björk and Skieller (15) or Molina and Ortiz Monasterio (6). We used measurements of cephalometric points in comparison with normal values (16). For maxillofacial growth (frontal), measures was compared to the contralateral normal side, since symmetry is one of the objectives of the treatment. Younger patients (Group I) showed a smaller difference in growth between the two sides, actually presenting similar facial growth for both sides after the distraction procedure. In this group, final clinical and cephalometric results were similar for both sides, and patients presented facial symmetry with good dental occlusion, which is another objective of the treatment.

In terms of older patients (Group II), we observed a more intense growth than in Group I. There was clinical and cephalometric improvement of facial asymmetry, but without reaching the degree of similarity reached by the younger group, resulting in incomplete facial symmetry and in dental occlusion that required orthodontic treatment for a longer period of time. All patients underwent orthodontic follow-up before and after distraction, according to the needs of each case.

The more intense growth among older patients happens because there is time for the development of a more serious facial asymmetry, which does not happen in younger patients. Therefore, there is a strong indication for the early treatment of patients, between 18 and 24 months of age. The early performance of distraction osteogenesis for treatment of hemifacial microsomia avoids secondary facial growth in the maxilla and orbit, produced by hypoplasia of the mandibular ramus and ascendent angle.

Acknowledgements. The authors thank Beatriz Ortiz Monastério and Implamed, exclusive distributor of Osteomed in Brazil.

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COMPARISON OF HYDROXYAPATITE CEMENT (BONESOURCE®) AND POROUS HYDROXYAPATITE (HA-40®) FOR CRANIOPLASTY IN RATS

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Preliminary experimental and clinical data on hydroxyapatite cement has shown high biocompatibility, osteoconduction capacity, structural stability and good clinical results. Its most remarkable advantage over other forms of hydroxyapatite compounds is the capacity of being molded to bone defects intraoperatively. The objective of this study was to compare the use of porous granular hydroxyapatite (HA-40®) and hydroxyapatite cement (Bonesource®) for cranioplasty in rats in terms of biocompatibility, osteointegration, osteoconduction and complications. Twenty-eight rats underwent craniectomy and cranioplasty using one of these biomaterials. Implants were histologically evaluated for biocompatibility, osteointegration and osteoconduction after 4 and 12 weeks. We found no statistically significant difference between the two groups. This study suggests that if both materials are comparable in terms of complications and histologic characteristics, hydroxyapatite cement could become an excellent alternative for craniofacial surgery because of its advantages in sealing and molding bone defects.

KEY WORDS: *Cranial defects, hydroxyapatite, cranioplasty, bone graft.*

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About 60 % of the calcified human skeleton are made of calcium phosphate in the form of hydroxyapatite (HA), whose composition is $Ca_{10}(PO_4)_6(OH)_2$. Certainly, this is one of the reasons why hydroxyapatite compounds are highly biocompatible and have remarkable osteoconductive capacity. These aspects have made HA one of the most widely used biomaterials for correction of craniofacial bone defects. There are two major forms of HA: ceramic and nonceramic. Synthetically produced or derived from marine coral skeleton, ceramic HA may be dense or porous. Dense HA is difficult to shape and does not have osteoconduction capacity, two unfavorable characteristics in craniofacial surgery. Porous HA in block form is fragile and also difficult to shape. Porous granular hydroxyapatite (GHA), which was the form of HA used in this study, permits osteoconduction but cannot be shaped either, and, in certain clinical situations, it has some undesired characteristics due to its granular presentation, such as troublesome handling and difficulty in keeping the implant in position (1). Hydroxyapatite cement (HAC) represents the nonceramic HA group. HAC is the only calcium phosphate cement that sets to a stable shape and converts *in vivo* to pure microporous hydroxyapatite at physiologic pH and temperature. When mixed with liquid HAC becomes a paste that sets in approximately 15 minutes and becomes impermeable to water within 4 hours. HAC is a new material and has been widely studied in the last years. Biocompatibility, osteointegration and osteoconduction have been documented by different authors (1-10). HAC is slowly replaced by bone without a significant loss of volume or change in shape (8,9). It keeps an excellent structural stability in non-stress bearing bone and its most remarkable advantage is the ability of being easily contoured to bone defects (6).

The objective of this study was to compare biocompatibility, osteointegration, osteoconduction and complications between porous granular hydroxyapatite (HA-40®) and hydroxyapatite cement (Bonesource®) for cranioplasty in rats.

MATERIALS AND METHODS

To carry out the study, we used 28 Wistar male adult rats weighing between 250 and 300 g (3-4 months). These animals underwent craniectomy and cranioplasty and were divided into three groups according to the material used in the cranioplasty (Group I: GHA ,12 rats; Group II: HAC, 12 rats; Group III: control, 4 rats). Surgical procedures consisted in: a) intraperitoneal anesthesia with sodium thiopental 30 mg/Kg; b) scalp tricotomy; c) "U" shaped incision with an occipital pedicle; d) periosteum excised from

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the cranium surface; e) 1.0 x 1.0 cm craniectomy; f) cranioplasty with 0.1 ml of HAC, GHA or nothing, depending on the group (the defect was left empty in the control group); g) closure of skin with nylon 5-0.
The evaluation of the implants was made in two phases, 4 and 12 weeks after surgery. Animals were sacrificed by overdose of sodium thiopental (120 mg/Kg) and their skulls sent to histologic preparation in formalin solution. Then, specimens were decalcified and cut into two halves in the center of the bone defect filled with the biomaterial. A histologic slide of this central edge of the specimens was made, including native bone and the implant, stained with hematoxilin and eosin. All specimens were histologically analyzed in a blind fashion by one pathologist from the Pathology Service at Hospital de Clínicas de Porto Alegre for biocompatibility, osteointegration and osteoconduction. Each specimen was rated from 1 to 4 according to the intensity of these variables. Grade 4 meant great biocompatibility, osteointegration and osteoconduction. Intraoperative and postoperative complications were registered.

RESULTS

The first phase, with 4 weeks, had only two animals of each group and, therefore, had no statistic power. It was planned to function as a pilot for the surgeon and pathologist and to give an early evaluation of the parameters of this study. The result of the histologic analysis of this phase is expressed in table 1. Group I (GHA) specimens evidenced less fibrosis between native bone and the implant, which means better osteointegration. Because of the precocity of this evaluation to evidence significant bone ingrowth through the biomaterials, osteoconduction could not have its real meaning and was considered as osteoid neoformation reaction. Group II (HAC) evidenced a greater osteoid reaction. Both biomaterials were highly biocompatible and were very similar in this aspect. No acute postoperative complications were registered.
In the second phase, with 12 weeks, the remaining animals were operated on. Results are expressed in figure 1, which contains medians and median intervals for the analyzed variables, that is, biocompatibility, osteointegration and osteoconduction (with real meaning in this phase). Data were analyzed by non-parametric Kruskal-Wallis test for multiple variables. The established significance of this study was 5% ($P<0.05$). Bone ingrowth through both biomaterials was evidenced in the specimens, confirming osteoconduction capacity of both forms of HA (Figure 2 and 3). No significant difference was statistically demonstrated between Groups I and II for all three variables.

The control group had the expected histologic behavior described in the literature. No late complications were registered, such as infection, extrusion or dislocation of the implant.

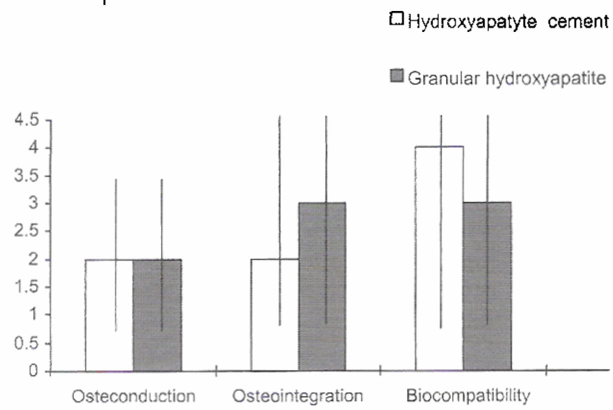

Figure 1. Histologic evaluation of cranioplasty materials (Phase 2). Specimens were evaluated in terms of osteoconduction, osteointegration, and biocompatibility, and graded from 1 to 4 (best).

DISCUSSION

Osteoid neoformation reaction begins immediately after craniectomy. The capacity and speed of bone ingrowth through the biomaterials, which means osteoconduction, depend on the characteristics of the material and on the metabolism of each animal species. In rats, an interval of 3 months is described as satisfactory to study osteoconduction. A significant bone growth is observed by that time.

Porous ceramic hydroxyapatite is already well studied (11-15). This is not true for hydroxyapatite cement, which is a new biomaterial. Nevertheless, a great number of new studies on HAC are trying to describe its histologic and clinical characteristics. In the present study, both biomaterials demonstrated similar histologic patterns, in a 3-month period, for cranioplasty in rats. This study suggests that if both materials are comparable in terms of complications and histologic patterns, hydroxyapatite cement could become an excellent alternative in craniofacial surgery, because of its advantages in sealing and molding bone defects. Its cement form can be easily

Table 1. Histologic evaluation: Phase 1

Variable	Hydroxyapatite cement[a]	Granular hydroxyapatite[a]	Control
Osteoid neoformation	4+/3+	3+/2+	2+/3+
Osteointegration	2+/2+	3+/3+	—
Biocompatibility	3+/4+	3+/4+	—

[a]Rated in blind fashion by one pathologist. Grade 4 = best performance in terms of the variables.

sculpted intraoperatively. Our experience with granular ceramic hydroxyapatite HA-40® is satisfactory, but in some situations the use of HAC with its contouring capacity was extremely gratifying.

Further research is needed on biomaterials to improve the therapeutic armamentarium of craniofacial surgeons when facing bone defects.

Acknowledgements. We are grateful to all persons who contributed to this study, in particular to Eliane Gomes and Jorge Alberto Lopes for their expertise in the histologic processing of bone specimens.

Figure 2. Granular porous hydroxyapatite (12 weeks) . Osteoconduction trhough the biomaterial.

Figure 3. Hydroxyapatite cement. After 12 weeks bone ingrowth easily evidenced.

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AUTOGENOUS AURICULAR CARTILAGE GRAFT ON NASAL DORSUM: EXPERIMENTAL STUDY IN RABBITS

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The purpose of this research project was to study the behavior of bylayer autogenous auricular cartilage graft in the nasal dorsum of 29 albino New Zealand rabbits. The grafts were sutured together with two 5-0 nylon stitches, leaving the perichondrium in contact with the dermis. The rabbits were divided into three groups. Animals in each group were sacrificed 2, 6 and 16 weeks after the operation. The degenerative and necrotic alterations observed were rated from 0 (absence) to 4 (total necrosis). Cartilage formation was rated from 0 (absence) to 3 (thickness > 2/3 of full thickness of cartilage). Ossification and calcification were classified in terms of presence and absence. Necrosis was observed in all groups, being more intense in the 16-week group. In this group, necrosis was greater in the internal layer than in the external layer. Neocartilage formation occurred similarly in all groups of rabbits. In each layer of the double autogenous auricular cartilage graft, necrosis was greater distally from the perichondrium and neocartilage formation was greater close to the perichondrium. Ossification was higher in the 16-week group, mainly in the internal layer. These findings strongly suggest that perichondrium has an important role in the survival of the graft, and that degenerative and regenerative processes are present in all cartilage grafts.

***KEY WORDS:** Cartilage, nose, autologous graft, New Zealand rabbits, auricular graft.*

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Autogenous cartilage grafting is a very useful and versatile procedure. It may be used for the reconstruction of ears, for filling in depressions, for correction of contour deformities or for the achievement of architectural support (1). On the face, grafts may also be used to correct malar and orbital deformities, such as fracture of the orbital floor (2,3).

The use of chondral grafts in rhinoplasty is well established in the medical practice. Several authors have been using autogenous auricular cartilage grafts in one or more layers, according to the amount of projection desired (1). There are reports in the literature showing that multi-layer grafts, used in nasal injuries, will have little or no alteration with time (4-6). Bert (1865) published the first report on autogenous cartilage graft in rats, showing viability as well as osteogenic formation (7). Fisher (1882) proposed that the survival of autogenous cartilage grafts depends on perichondrium (8). In 1941, Dupertuis reported on the growth of transplanted segments of auricular cartilage in young rabbits (9). Several authors published papers on the role of the perichondrium in cartilaginous formation (10-13). Duncan et al. (14) showed that two pieces of autogenous auricular cartilage graft (AACG) in rabbits, sutured together with perichondrium, had more chances of survival, chondrogenesis and resistance to distraction when compared to grafts without perichondrium. Zalzal et al. (15) showed similar rates of survival for grafts with or without perichondrium implanted on the subcutaneous tissue on rabbits, in a 2 to 4 month range. However, the histopathologic changes and the role of the multi-layer grafts have not been definitively described. The objective of the present study was to investigate the occurrence of histopathologic changes using bylayer AACG with perichondrium over the nasal bone of rabbits.

MATERIALS AND METHODS

Twenty-nine female white New Zealand rabbits, aged 6 to 7 months, were submitted to intramuscular analgesia with ketamine hydrochloride (35mg/kg) and acepromazine (0.45mg/kg). During surgery, anesthesia was augmented with local infiltration of 0.2% lidocaine with epinephrine (1:200.000) in the ears and nasal dorsum.

Cartilage grafts were harvested from the anterior aspect of the right ear, through a longitudinal incision 2 cm away from the base of the ear. The graft was removed with the anterior perichondrium layer, leaving the posterior perichondrium intact. Two grafts (10 x 10 mm)

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were obtained, in which the superior surface was with perichondrium and the lower surface was without perichondrium. They were piled and sutured with two 5-0 nylon stitches on the opposite ends. They will be referred to as bilayer cartilage grafts (figure 1).

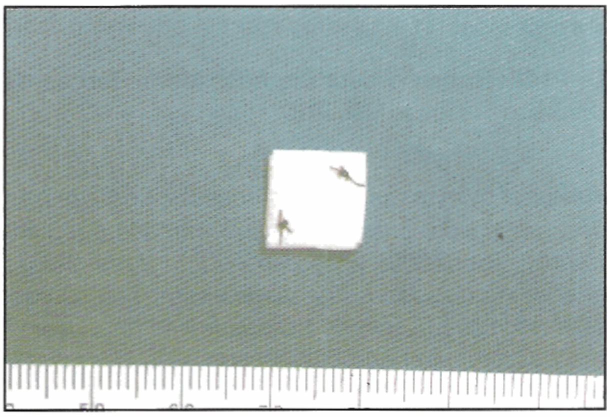

Figure 1. Bylayer autogenous auricular cartilage graft in rabbits, sutured together with 5-0 nylon.

In each animal, a bilayer cartilage graft was implanted over the nasal dorsum, above the osseous tissue without periosteum, through a 15 mm incision on the cranial vault between the two orbits. The animals were anesthetized and sacrificed 2 weeks (nine animals); 6 weeks (nine animals); and 16 weeks (11 animals) after the operation.

Histopathologic analysis

The grafts were removed and dyed with hematoxylin-eosin (HE). At least one 100x field was disregarded in each extremity of the cartilage to avoid the influence of the 5-0 nylon stitch on the graft. Histologic modifications were scored in terms of qualitative and semi-quantitative variables which could be statistically analyzed (16).

Each graft layer was analyzed in terms of degeneration and necrosis, cartilage formation, and ossification and/or calcification. The degenerative and necrotic alterations observed were rated from 0 (absence) to 4 (total necrosis). Cartilage formation was rated from 0 (absence) to 3 (thickness > 2/3 of full thickness of cartilage) (table 1). Ossification and calcification were classified in terms of presence and absence. External and internal graft layers were individually evaluated.

RESULTS

Degenerative and necrotic alterations

In the 2-week group, there was evidence of necrosis in all grafts, both in the inner and outer layers. The scores for this group ranged from 1.8 (external layer) to 1.78 (internal layer) (figures 2 and 3). There was a statistically significant increase in necrosis with time. In the 16-week group, the internal layer showed more necrosis when compared to the external layer (score rates 3.45 and 2.8 respectively). In the 2-week group, total necrosis (score 4) occurred in 45% of the animals (figure 4).

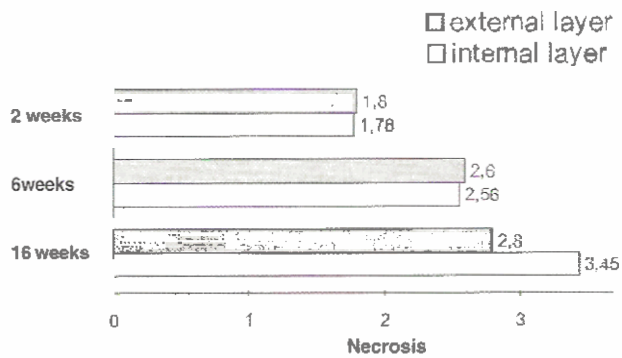

Figure 2. Average score of necrosis in the 2, 6, 16-week graft groups.

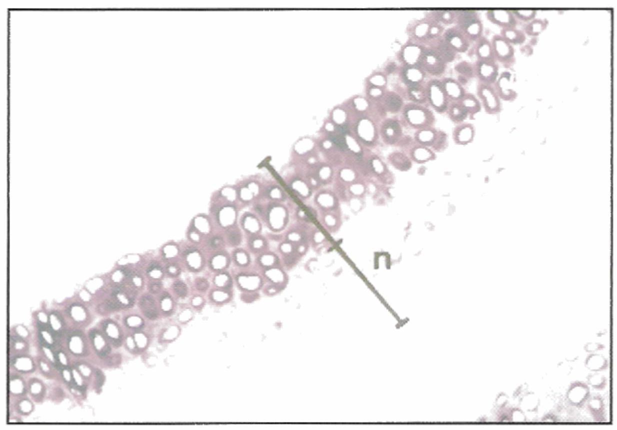

Figure 3. Two-week group (HE 100x). Bilayer cartilage graft showing necrosis (n) of the external layer, ranging from 1/3 to 2/3 of the full thickness of the cartilage (score 2).

Table 1. Scores for evaluation of alterations in graft layers

Score	Degeneration and necrosis	Cartilage formation
	Absence of degeneration and necrosis	Absence of neocartilage formation
	Necrotic area = 1/3 of the full thickness of the cartilage	Cartilage formation = 1/3 of the full thickness of the cartilage
	Necrotic area > 1/3 to 2/3 of the full thickness of the cartilage	Cartilage neoformation > 1/3 to 2/3 of the full thickness of the cartilage
	Necrotic area > 2/3 of the full thickness of the cartilage	Cartilage formation > 2/3 of the full thickness of the cartilage
	Total necrosis of the cartilage	

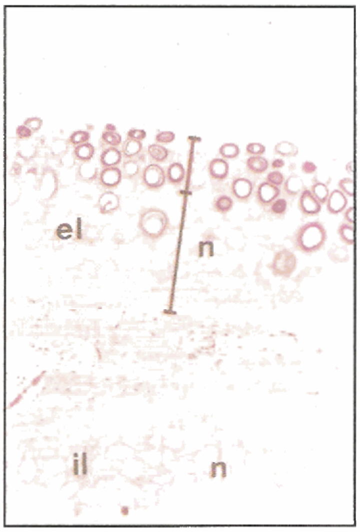

Figure 4. Sixteen-week group (HE 100x). Total necrosis (n) can be observed in the internal layer (il) (score 4) and 2/3 of necrosis in the external layer (el) (score 3).

Neocartilage formation

Neocartilage formation occurred mainly by superposition, where cells of the deep perichondrium divided and differentiated in chondrocytes that were added to the graft.

Neocartilage formation was observed in the 2-week group (figure 5), and did not increase with time. In the 16-week group, neocartilage formation was higher in the external layer than in the internal, with no significant difference (figure 6).

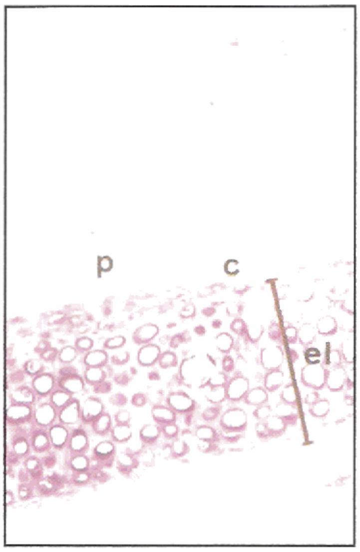

Figure 5. Two-week group (HE 100x). Neocartilage formation (c) from the perichondrium (p) equivalent to < 1/3 of the full thickness of the external layer (el) (score 1).

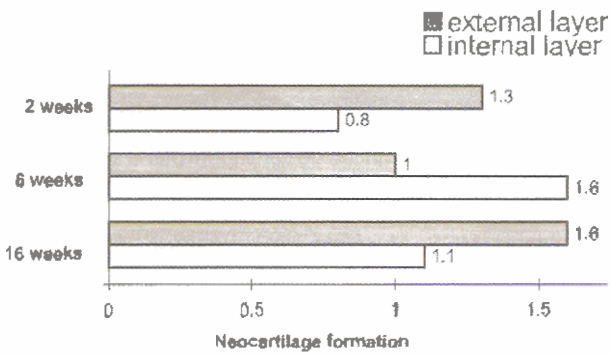

Figure 6. Average score of neocartilage formation for the 2, 6, and 16-week graft groups.

Ossification and/or calcification

In the 2-week group and in the 6-week group only one animal in each group presented ossification on the external layer of the graft. This also happened in the internal layer for one rabbit in the 2-week group and another in the 6-week group. Ossification/calcification increased in the 16-week group, mainly in the internal layer (figure 7).

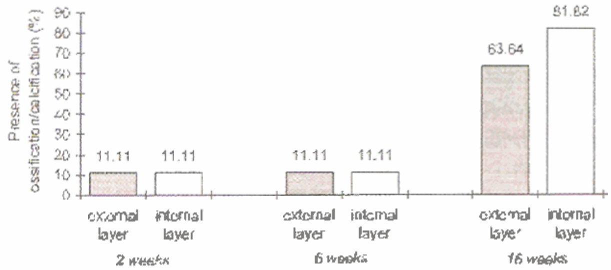

Figure 7. Percentage of ossification/calcification in the 2, 6, and 16-week graft groups.

These findings showed degenerative processes in the cartilage graft with cartilage formation and ossification mainly in longer periods (figures 8-10).

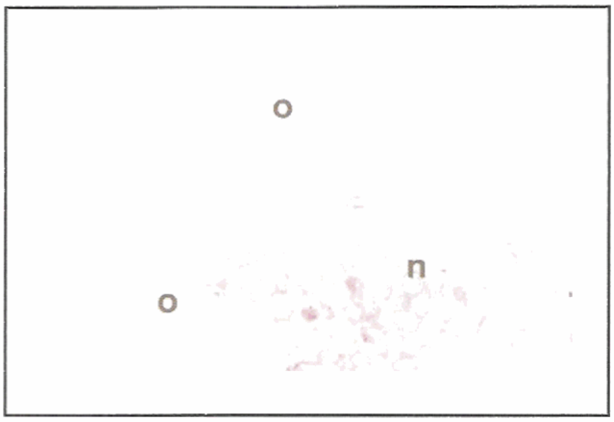

Figure 8. Sixteen-week group (HE 100x). Total necrosis (n) of cartilage with areas of ossification (o) over the graft, beginning transformation from graft to bone.

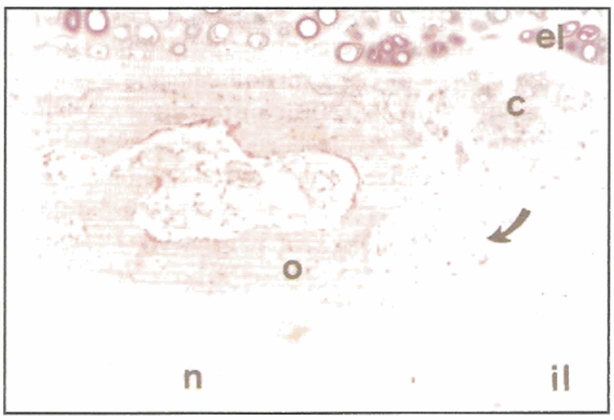

Figure 9. Sixteen-week group (HE 100x). Neovascularization (↘) between the two layers of cartilage graft, with the presence of cartilage formation (c) and osteogenesis (o). n = necrosis; el = external layer; il =internal layer.

Figure 10. Sixteen-week group (HE 100x). Total necrosis (n) of the cartilage graft with osteogenesis (o).

DISCUSSION

Several cartilage grafts are transplanted to the nose in spite of the lack of soft tissues and a rather tight pocket. In our study, the external layer of the graft that was below the dermis presented less degenerative alterations or necrosis than the layer over the nasal bone. AACG is more feasible when the recipient bed is highly vascularized.

The grafts had perichondrium in one of their surfaces, which was in contact with the dermis, and necrosis was higher distally to the perichondrium. This stresses the role of the perichondrium in tissue reparation (8,14).

Cartilage formation occurred by superposition, which was already described by Junqueira & Carneiro (18). In the present study, this phenomenon occurred close to the perichondrium, showing its chondrogenetic potential, as related in the literature (12,13,19,20).

Neocartilage formation occurred after 2 weeks, in spite of the low rates observed. This also happened with other authors who observed cartilage growth by superposition, in coastal cartilage grafts of rats, after 10 days (21). Cartilage formation begins after 2 weeks (22,23).

The late ossification on the external and internal layers observed in our series, was observed by other authors (7,10,23). Clark & Clark related cartilage formation and ossification in rabbit ears, after capillary neoformation over the cartilaginous tissue (24). In our current research the ossification phenomenon was more intense in the internal layer, next to the nasal bone, suggesting that the necrosis of this layer promoted higher ossification.

Several publications reported that cartilage grafts do not present clinical alterations in terms of shape and volume (4-6). Nevertheless, the study reported here showed degenerative alterations (necrosis) and regeneration (neocartilage formation and ossification) suggesting that they are responsible for the maintenance of the shape and volume of the cartilage grafts.

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SECONDARY CHEILOPLASTY WITH REORIENTATION OF THE ORBICULARIS ORIS FIBERS

Eudes Soares de Sá Nóbrega, MD[1]

Over the last 8 years we have observed an elevated number of cleft lip patients operated on with an aesthetic result below the expected. We decided to study and to use the principles of reorientation of the orbicularis fibers proposed by Park and Ha, where they demonstrate the importance of muscle reorientation during the primary lip surgery. Here we utilize those technical details in order to correct the muscle layer inappropriately repaired during the primary surgery. This brought us better results with excellent anterior-posterior projection of the cleftlip sub-unit and with adequate muscular function. Anatomical considerations will be mentioned, a surgical case is presented, and finally results are shown. We strongly believe that this technical innovation will be as useful for the secondary cheiloplasty as McComb's ala repair has been for the cleft lip nose in the last decade.

KEY WORDS: *Unilateral cleft lip, sub-unit of the upper lip*

Braz J Craniomaxillof Surg 1998;1(1): 23 - 26

Over the last 8 years we have observed an elevated number of cleft lip patients operated on with an aesthetic result below the expected (figure 1).Recently, we had an opportunity to appreciate some of the work of Michelangelo,[2] when we noticed that in order to achieve his great results on the hard surface of the marble, he started with a meticulous muscular anatomical study (figures 2A and 2B). Coincidentally, at that same period of time we came across the work of Park and Ha (1), which reinforced the importance of muscle repair on the primary cleft lip surgery. Even further, as admirers of Burget's (2) sub-unit principles (figure 3), we decided to use these elements together for the enhancement of our results.

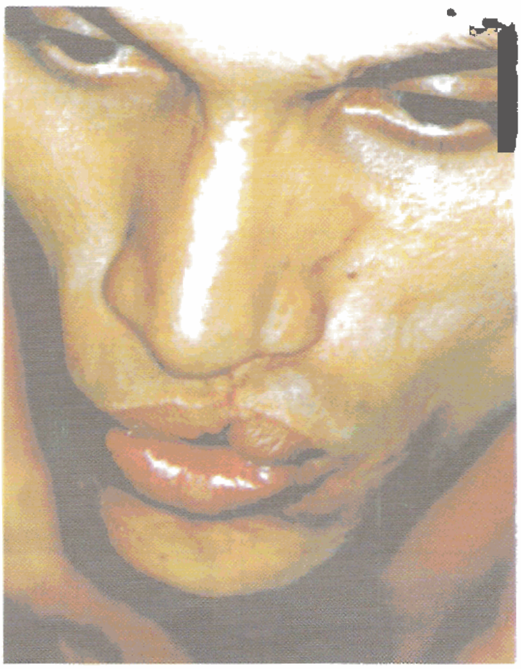

Figure 1. Inappropriate repair of the muscle resulting in a whistling deformity, a sulcus where the philtrum column should be, and an orbicularis muscle bulge.

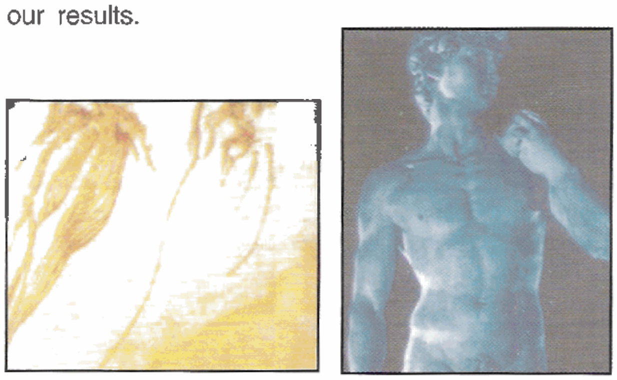

Figure 2. A) Michelangelo's original anatomical study in order to sculpture a leg; B) Michelangelo's David. Every muscular detail can be observed "underneath" the marble "skin."

According to the previously mentioned paper of Park and Ha, the orbicularis oris is in fact two muscular units: a superficial and a deep one, each with distinct functions (figures 4A and 4B). The deep portion extends from one modiolus to the other. It closes the oral cavity as constrictor, while the superficial one is connected to the muscles of the facial expression and opens up the mouth as a retractor. When the mouth is tightly closed (figure 5A) by contraction of the deep portion of the orbicularis and relaxation of the superficial portion, we notice wrinkling and thickening of the skin around the vermilion, an accentuation of the perioral wrinkles, an increase in prominence of the philtrum columns and a flattening of the naso-labial sulcus. When in contrast the mouth is opened (figure 5B), there is a contraction of the superficial portion of the fibers and a relaxation of the deep portion. The naso-labial sulcus is deepened, and at the same time the relaxation of the

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[2] MASP (São Paulo) – Art Museum. Exhibition of Casa Buonarroti from Florence, São Paulo, October, 1997.

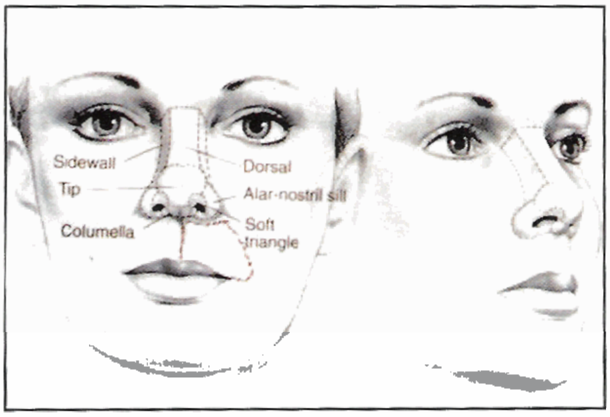

Figure 3. Picture taken from Burget's book with the upper lip sub-unit added (2).

deep portion causes a thinning of the vermilion. This surgical approach is based on the anatomical restoration of the continuity of the orbicularis fibers according to their layers, superficial and deep, and on the anatomical use of the lateral lip as an aesthetic sub-unit of the face (figure 3).

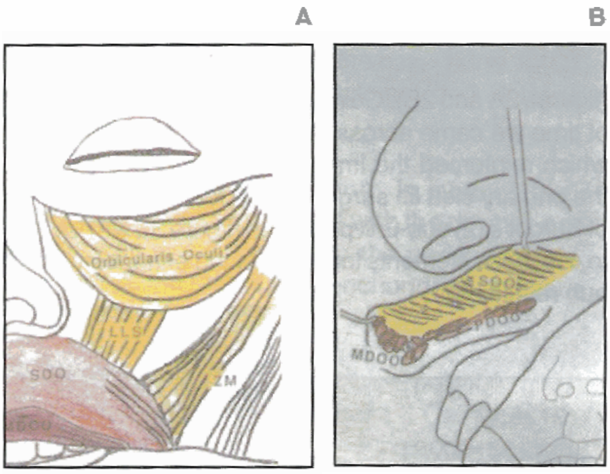

Figure 4. Original anatomical representation of A) the superficial and B) the deep portions of the orbicularis, proposed by Park and Ha.

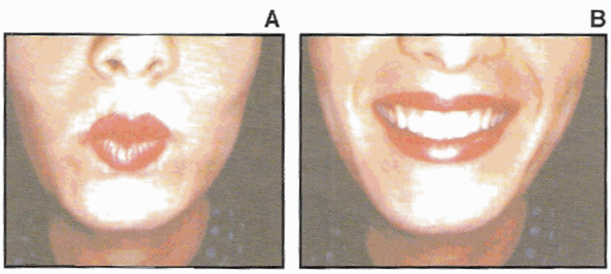

Figure 5. A) Functioning of the deep portions of the orbicularis oris; B) functioning of the superficial portions of the orbicularis oris (see text for details).

We mark the middle of the dimple (figure 6A) medially and the naso-labial sulcus laterally with brilliant green. Infiltration of xylocaine with epinephrine (1:200.000) is performed within these boundaries. We excise the old scar and undermine subcutaneously with Stevens scissors until we reach those previously marked edges (figures 6B, 6C, and 6D). We also undermine the muscle from the oral mucosa within these limits. The second step is to identify the superficial and the deep layers of the orbicularis and to suture them separately (figure 6E). The superficial is sutured pants over vest with the medial border on top of the lateral one using 4-0 horizontal mattress sutures in order to mimic the philtrum columns. The deep portion is then sutured under the vermilion end to end with the same material, thus restoring continuity of the deep ring (figure 6F). After that we resect the excess of lateral mucosa gained with this maneuver. Subdermal suture is done with monofilament synthetic absorbable suture(5-0) and the skin with 6-0 nylon.

We observe that this method offers a better projection of the whole lip sub-unit (figures 7A and 7B), a better positioning of the ala, and most of all, the restoration of the integrity of the movements of the lip. Disadvantages are: It is a time consuming operation and the edema lasts 1 and a half weeks longer than the edema in the other conventional methods (figure 8). A few weeks later, the definitive result can be appreciated (figure 9). Three months after the surgical procedure, when about 80 to 90% of the edema have disappeared, we can observe the great improvement in the function of the muscle by telling a patient to purse the lips in a kiss manner, and by telling him to smile (figure 10).

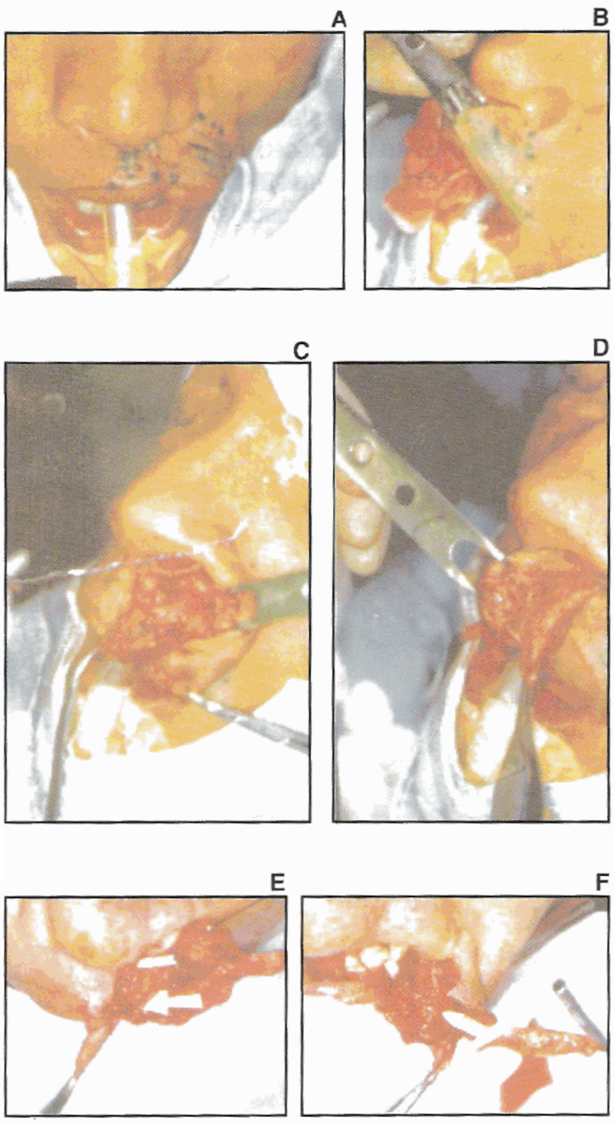

Figure 6. Surgical technical details: A) demarcation; B, C, D) undermining; E) finding the two different muscular portions; F) muscle distinct suture (see text for details).

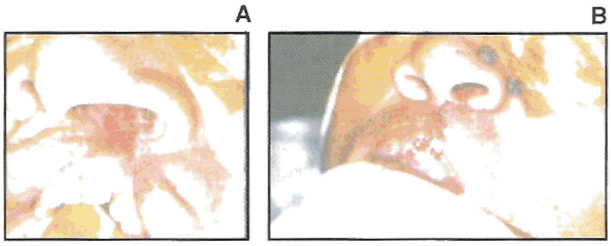

Figure 7. A and B) 42-year-old patient. Notice the projection of the lip sub-unit, the symmetry of the alae and the thickness of the vermilion (primary case).

Figure 8. A) 27-year-old patient previously operated on elsewhere; B) 7 days post op, after the procedure was performed for revision of the lip; C) pursing the lips in a kiss manner pre op; D) 7 days post op, pursing the lips.

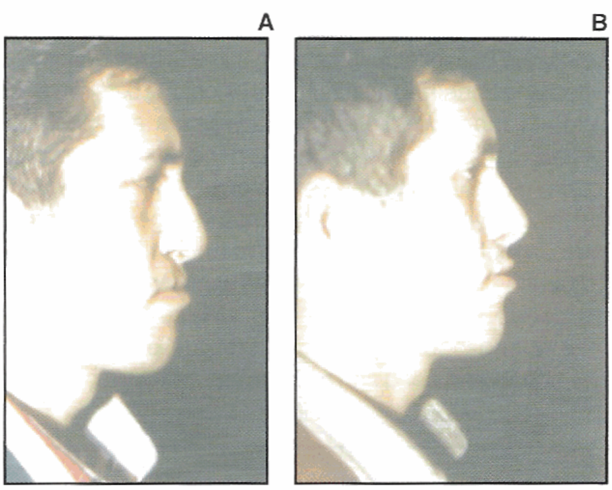

Figure 9. Notice the improved relationship between the upper and the lower lip of this patient who underwent the procedure 6 months earlier. He has not undergone orthognathic surgery because he refused it.

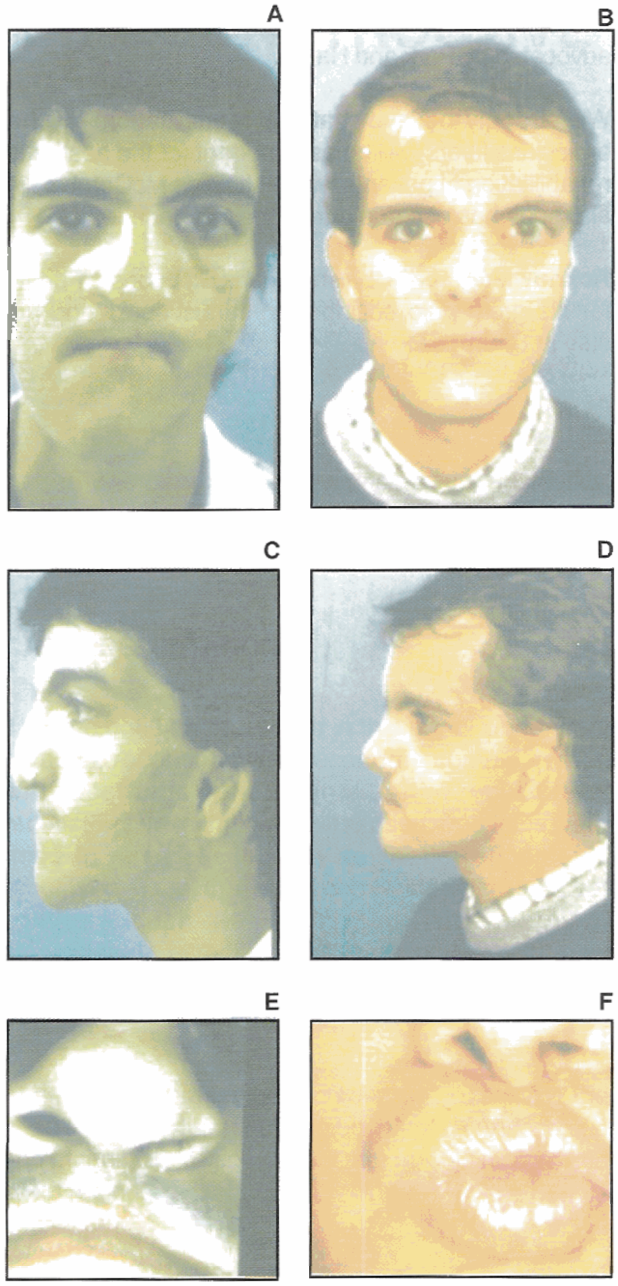

Figure 10. Patient with hemifacial microsomia and cleft lip and palate (complete left transforamem) had orthognathic surgery 1 year ago, and 3 months after that underwent a muscular reorientation procedure.

We have observed that until the beginning of this last decade many of the published papers on this matter focused only on the skin incisions; in other words, their authors' main concern was to gain enough skin to provide adequate height at the cleft. Only a few authors have given due importance to the perioral muscles. As a matter of fact we can observe that the majority of all the photographs showed in those articles are always of the patient "resting," never showing a smiling or puckering picture postoperatively. We can observe every day in our offices or clinics that the lip sub-unit is a complex structure whose dynamic shape depends on the appropriate restoration of its muscular elements. Today we witness the advancement of the techniques employed for surgical rejuvenation of the face by restoring muscle tonicity in order to obtain more physiological and long lasting results.

This concept can also be employed for both primary and when necessary for secondary cheiloplasty, as was advocated by Park and Ha (1).

We strongly believe that the reorientation of the orbicularis fibers will be as important for the aesthetic rehabilitation of patients with cleft lip as McComb's (3) ala repair has become during the last decade.

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AESTHETIC ASPECTS OF RECONSTRUCTIVE SURGERY

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The paper presents and discusses five cases of reconstructive surgery for which a functionally and aesthetically adequate solution has been proposed. Although several reconstructive techniques were used, free flaps were used in most cases. Cases are presented according to the region of the head they refer to: frontal region, parotidic-masseteric and mandibular region, orbital region, chin region, and scalp region. Although the restitution of function is the main priority in all reconstructive processes, the guarantee of a normal social life may sometimes depend on good aesthetic results as well.

KEY WORDS: *Head and neck surgery; reconstruction; aesthetics.*

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In plastic surgery, patients' expectations regarding positive results are certainly higher in the case of patients who seek help for cosmetic purposes. We have noticed, however, that there is an increasing interest in aesthetic results also on the part of patients who undergo major trauma or post-extensive oncologic resections. Surgical teams admittedly tend to have different evaluation criteria for patients who undergo reconstructive surgery and for patients who seek help for particular aesthetic purposes. Therefore, the concern with an adequate cosmetic result is, in most cases, restricted to aesthetic procedures, whereas this aspect does not seem to be crucial when the procedure is chiefly reconstructive. In major reconstructions, the choice of the best donor zone in terms of amount and size may be a matter of difficult solution. The choice between correction of the recipient zone and the inevitable aggression to the donor area is a delicate issue. The new options within the range of available reconstructive procedures, as for instance the introduction of free flaps, offer new possibilities for correction in major reconstructive procedures. Free flaps are becoming increasingly more common, due to their broad mobility, easiness of molding, and capacity for correction in cases of significant tissue loss. Therefore, flaps are also subject to the aesthetic demands presently studied. It is a known fact that, throughout history, reparations have been carried out with the aim of strictly solving functional aspects, relegating aesthetic matters to a lower degree of importance. Presently, however, there is another kind of concern: Finding solutions that are both functional and aesthetically adequate. Therefore, this paper presents and discusses five cases of reconstructive surgery for which a functionally and aesthetically adequate solution has been proposed.

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CASE PRESENTATION

The five patients presented in this paper underwent complex reconstructive procedures complemented with aesthetic refinements. Although several reconstructive techniques were used, free flaps were used in most cases. The aesthetic refinements employed were the ones conventionally used for routines such as liposuction, lipoinjection, liposculpture, elimination of scars in places of easy dissimulation, tissue expansion, hair transplant, and others.

The cases are presented according to the region of the head they refer to: frontal region, parotidic-masseteric and mandibular region, orbital region, chin region, and scalp region.

Frontal region

The frontal region is one of the most exposed areas of the head and, therefore, the treatment of frontal injuries presents technical difficulties.

Case 1. R. H. is a white 27-year-old male, single, who was in a car crash in December, 1996 and suffered loss of scalp and fracture of frontal bone. He was referred to the Reconstructive Microsurgery and Plastic Surgery Service at Hospital de Clínicas de Porto Alegre, where a surgical correction was recommended with transference of an antebranchial free flap. The flap was transferred using the recipient's pedicle of cervical vessels (external carotid in termino-lateral anastomoses and external jugular vein).There was a positive evolution of the fracture. However, from an aesthetic point of view, the presence of glabrous tissue in the frontal region left a noticeable sign of the reconstruction. The patient was then submitted to a

new surgery, for hair transplantation, with the aim of dissimulating the glabrous region. The case had a favorable evolution.

Parotidic-masseteric and mandibular regions

The parotidic, masseteric and mandibular resections cause functional and aesthetic deficits. As a result, the lack of symmetry in these zones is extremely evident, since its visualization in confrontation with the jaw edges brings out the lesion.

Case 2. R. C. is a white 17-year-old female, single, who underwent an extensive mandible tumor resection (ameloblastoma) with the Head and Neck team. During the same surgery, the reconstruction was carried out by the Reconstructive Microsurgery and Plastic Surgery team, with transference of fibula free-flap shaped as body and ramus of the mandible.

Since the condylar process and the neck of the resected hemi-mandible were free of lesion, they were preserved. The fixation to the fibula was made using metal wiring and the fibula and graft were implanted in the glenoid cavity. The cervical receptive vessels used were the external carotid artery in termino-lateral anastomoses and the external jugular vein. During the postoperative period, the reconstruction was made evident by the depression under the body of the reconstructed neo-mandible. In order to improve aesthetics, two subsequent lipoinjection procedures were carried out, with material removed from the internal face of the knee. Presently the aesthetic aspect is adequate and the bilateral symmetry is fine.

Orbital region

Enucleations are deforming. For this reason, the reconstruction of the orbital cavity which enables an adequate insertion of prosthesis has a good cosmetic result which allows patients to have a normal social life. Again, we would like to point out the fact that additional scars should be placed in regions of less evidence, such as the pre-auricular zone.

Case 3. J. S. is a black 41-year-old male, married, who suffered severe trauma in the face with laceration of eyeball and destruction of the orbital cavity content by infection. The problem was solved. However, the patient came to the Reconstructive Microsurgery Unit and Plastic Surgery Service in order to solve the retraction of the orbital cavity, which was blocking the insertion of prosthesis. A broad reconstruction of the orbital cavity was recommended, with opening and filling with free-flaps from dorsalis pedis.

The extensive pedicle was introduced through a tunnel and anastomosed to temporalis superficial vessels. The wide and complete opening of the orbital cavity allowed the insertion of a prosthesis, with good configuration and adequate aesthetic results.

Chin region

Resections which involve the body of the mandible are deforming, since they involve a medial region of the face. Under such circumstances, alterations in symmetry are usually significantly evident, with big deformities in the chin region.

Case 4. E. V. is a white 27-year-old female, single, who was referred to the Reconstructive Microsurgery and Plastic Surgery Service 1 year after undergoing a complex resection of the body and part of the two rami of the mandible due to an ameloblastoma. Besides the major damage in functional aspects, the aesthetic deficit was also evident.

A reconstruction of the body and of the two rami of the mandible with a fibula free-flap was indicated. Cervical vessels were used as receptive vessels and the fibula was sectioned on its medium part so as to simulate the mandibular symphysis. The following microanastomoses were performed: fibular artery termino-terminal anastomosis in the external carotid artery, and fibular vein termino-terminal anastomosis in the external jugular vein. The case evolved without abnormalities allowing the insertion of dental prosthesis, which enabled chewing. Besides that, there was a considerable improvement in the aesthetic aspect.

Scalp region

Losses of scalp, depending on their location or extension, can not be easily dissimulated by the hair style. Due to this fact, the reconstructive procedures with tissue expansion provide favorable reparation.

Case 5. M. S. is a 7-year-old who suffered burnings in the scalp at age 3. After the treatment, the patient had scar retractions, frequent ulcers, and a poor aesthetic appearance. The patient was referred to the Reconstructive Microsurgery Unit and Plastic Surgery Service with indication for a reconstruction with tissue expansion. In the

first surgery the patient underwent insertion of an expander (800ml), in the remaining hair zone of the scalp. After the expansion, in a second surgery, the scar and glabrous zones were replaced with hair tissue of good quality. One expansion was enough to cover the entire scar zone.

DISCUSSION

Almost 20 years ago, Frank McDowell[3] stated in his editorial that the old idea of "plastic" surgery as shaping or sculpting still remained as the central issue in our specialty. In this editorial, flap refinement was mentioned, and 10 items of refinement were quoted.

In the last 20 years, our specialty has gone through an era of discoveries and developments which, undoubtedly, have changed a series of concepts: The development of free-flaps, myocutaneous flaps, liposuction, liposculpture, hair implant, peripheral nerve surgery, tissue expansion, videoendoscopy, and laser techniques brought about changes in a series of procedures.

Results which could be considered of good cosmetic quality until a few years ago may now be catalogued as poor under this new prevailing approach. Everyone who has followed such evolution may feel that they could have done better, when going over their photographic record files.

Actually, such an evolution with remarkable modifications in technical criteria has deeply changed the final expectation as regards the present cases; the level of expectation is much higher nowadays.

We should state clearly, however, that all aesthetic concerns are subject to a previous resolution of functional problems. The functional priority is evident in all reconstructive processes, and aesthetics comes on a supporting level in the rank of importance. Still, it is obvious that a possible functional-aesthetic association is the ultimate goal.

In social interactions, the first zone to be observed is the face. Even before verbal communication, there is a natural tendency to establish a visual contact with the face of the speaker. Since this is a region of great evidence, it becomes maybe the most important focus of reconstructive procedures from an aesthetic point of view. The different aesthetic areas of the face are particularly evident, and due to this fact, possible injuries in this region become fairly difficult to hide. Under such circumstances, the good use of natural folds, line of hair implants, and placement of scars in pre-auricular zones is imperative for the achievement of good results. In the superior and inferior limbs, functional aspects should be a priority in the repairing project. We must point out, however, that all along the various reconstructive phases aesthetic aspects should be emphasized, so that a high-quality result is achieved. Once this is done, the entire process will become more simple. Nevertheless, in some cases the chances for aesthetic improvement can only be assessed after major functional aspects are solved.

In case 1 (reconstruction of frontal region), after the cutaneous reconstruction, the gap in the hair zone was apparent, requiring a hair transplant. Among several reconstructive methods, such as tissue expansion and posterior rotation of hair zone, we chose transplantation of a free-flap. The case is still under evolution and another procedure of hair transplant might be necessary to achieve the final expected result. The patient is fairly satisfied with the aesthetic results.

In case 2 (reconstruction of hemi-mandible with fibula), the preservation and use of the neck and the condylus of the resected hemi-mandible allowed an excellent functional result. When the remaining condylus is free of lesion, grafting is the best choice, since it avoids reconstruction of the articulation with its expected functional difficulties. After fixation of the graft to the extremity of the transplanted fibula, all the set is fit into the temporo-mandibular articular zone, and the articular capsule is remade. After the fibulo-mandibular synthesis of the mandibular body zone, the vascular microanastomoses are made. In case 2 there was integration of the graft and a preservation of the temporo-mandibular articulation, with good quality results. In the postoperative period, a depression on the face at the level of mandibular ramus was evident. The two grafting procedures were carried out at 8-month intervals, approximately. They were made with overcorrection, and the post-operative aspect is good in terms of aesthetics and symmetry. The use of fat from the internal side of the knee seems to allow good integration and little absorption, as is made evident by the evaluation of this patient.

In case 3 (reconstruction of orbital cavity) the aesthetic need was a personal requirement of the patient, who sought a prosthesis implant on his own. Upon examination of the case, it became clear that an ocular implant in the zone of retraction would not be possible. Therefore, a reconstruction was recommended. Other techniques could have been used, such as grafting or local flaps. A dorsalis pedis free flap was chosen due to the possibility of using a thin cutaneous coverage, with a long vascular pedicle.

In case 4 (reconstruction of mandible) we achieved a good functional result, although the shape of the symphysis was not good. We believe that it is necessary to break the fibula many times to mold a true mandible shape.

In case 5 (expansion of the scalp), the use of an expander allowed the creation of tissue to cover the scar region in the scalp. The placement of the expander in a healthy hair zone in this young boy had good results, with enough hair flap to reconstruct the defect.

In conclusion, the search for good aesthetic results does not depend on the complexity of reconstructive or cosmetic cases, but rather on the interest in searching for the best alternatives in each particular case.

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Acknowledgments

These should be included at the end of the manuscript if relevant. Authors must acknowledge financial support from funding institutions. Persons who have contributed intellectually to the work but whose contributions do not justify authorship should be named in this section.

References

References should be numbered consecutively in the order in which they are first mentioned in the text. Inside the text, references will appear in parentheses: "As several authors (1, 4, 7) have noted...." References which appear for the first time in tables or figures must be numbered in accordance with the sequence established by the first identification in the text of the particular table or figure. Examples of different types of references are shown below:

Journal Articles

Standard article:

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If the article has more than six authors, the first six names should be cited followed by "et al.":

Parkin DM, Clayton D, Black RJ, Masuyer E, Friedl HP, Ivanov E, et al. Childhood leukaemia in Europe after Chernobyl: 5 year follow-up. Br J Cancer 1996;73:1006-12.

Organization as author:

The Cardiac Society of Australia and New Zealand. Clinical exercise stress testing. Safety and performance guidelines. Med J Aust 1996;164:282-4.

No author given:

Cancer in South Africa [editorial]. S Afr Med J 1994;84:15.

Volume with supplement:

Shen HM, Zhang QF. Risk assessment of nickel carcinogenicity and occupational lung cancer. Environ Health Perspect 1994;102 Suppl 1:275-82

Issue with supplement:

Payne DK, Sullivan MD, Massie MJ. Women's psychological reactions to breast cancer. Semin Oncol 1996;23(1 Suppl 2):89-97.

Letters and other special articles:

Enzensberger W, Fischer PA. Metronome in Parkinson's disease [letter]. Lancet 1996;347:1337.

Books and other monographs

Personal author(s):

Ringsven MK, Bond D. Gerontology and leadership skills for nurses. 2nd ed. Albany (NY): Delmar Publishers; 1996.

Editor(s), compiler(s) as author(s):

Norman IJ, Redfern SJ, editors Mental health care for elderly people. New York: Churchill Livingstone; 1996.

Chapter in a book:

Phillips SJ, Whisnant JP. Hypertension and stroke. In: Laragh JH, Brenner BM, editors. Hypertension: pathophysiology, diagnosis and management. 2nd ed. New York: Raven Press; 1995. p. 465-78.

Conference proceedings:

Kimura J, Shibasaki H, editors. Recent advances in clinical neurophysiology. Proceedings of the 10th International Congress of EMG and Clinical Neurophysiology; 1995 Oct 15 19; Kyoto, Japan. Amsterdam: Elsevier; 1996.

Conference paper:

Bengtsson S, Solheim BG. Enforcement of data protection, privacy and security in medical informatics. In: Lun KC, Degoulet P, Piemme TE, Rienhoff O, editors. MEDINFO 92. Proceedings of the 7th World Congress on Medical Informatics; 1992 Sep 6-10; Geneva, Switzerland. Amsterdam: North-Holland: 1992. p. 1561-5.

Dissertation:

Kaplan SJ. Post-hospital home health care: the elderly's access and utilization [dissertation]. St Louis (MO): Washington Univ; 1995.

Other published material

Newspaper article:

Lee G. Hospitalizations tied to ozone pollution: study estimates 50,000 admissions annually. The Washington Post 1996 Jun 21; Sect. A:3 (col 5).

Audiovisual material:

HIV+/AIDS: the facts and the future [videocassette]. St Louis (MO): Mosby-Year Book; 1995.

Forthcoming publications:

Leshner AI. Molecular mechanisms of cocaine addiction. N Engl J Med. In press 1996.

Electronic material

Journal article in electronic format:

Morse SS. Factors in the emergence of infectious diseases. Emerg Infect Dis [serial online] 1995 Jan-Mar [cited 1996 Jun 5]; 1(1):[24 screens]. Available from: URL: http://www.cdc.gov/ncidod/EID/eid.htm

Monograph in electronic format:

CDI, clinical dermatology illustrated [monograph on CD-ROM]. Reeves JRT, Maibach H. CMEA Multimedia Group, producers. 2nd ed. Version 2.0. San Diego: CMEA; 1995.

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Tables should be typed on separate pages and numbered consecutively using Arabic numerals (table 1, table 2, etc.). All tables must be mentioned in the text. Abbreviations should be explained in footnotes at the end of the table. For table footnotes, use superscript letters.

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