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Short Communication

Mandibular Reconstruction: a Clinical Evaluation of the La-CO-CE Segmental Defect Classification System

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Abstract

Objective: To evaluate the clinical outcome of mandibular segmental defect reconstructions using the La-Co-CE defect classification system.

Method: Patients reviewed were those who had mandibular resections for benign tumors from January 2010 to December 2012 and were retrospectively studied between Jan 2015 and Nov 2016. All resections and reconstructions were done under general anesthesia by the authors and outcome assessment was performed by a single separate surgeon. Outcome was assessed at a minimum of 24months after reconstruction was carried out. For all comparisons, $P < 0.05$ was adopted as the criterion for establishing a statistical significance.

Results: Twenty-seven patients in total were enrolled for this study; there were 9 males (33.3%) and 18 females (66.6%). Age range was 17-65 years with a mean of 33.1 ± 10.9. Twenty six subjects had reconstruction with titanium reconstruction plate used as alloplast and only 1 had acrylic alloplastic reconstruction. Nine (9) subjects had immediate reconstruction with iliac crest bone graft, 3 had delayed reconstruction with iliac crest bone graft while 15 are yet to have reconstruction done. None of the patients with delayed reconstruction had good facial and jaw cosmesis while 8 of the immediate reconstruction and 4 of no bone graft had good facial and jaw cosmesis.

Conclusion: Classification of the envisaged surgical reconstructive difficulty using the La- Co-CE segmental defect classification system enables objective evaluation of the outcome and permits objective comparisons of reports in the literature.

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INTRODUCTION

The mandible is a major component of the human face. It provides a mobile platform for the dentition and a mobile frame for insertion of masticatory, tongue and supra-hyoid muscles. It plays important functional roles in mastication, speech, deglutition, phonation, oral competence and facial aesthetics [1-5]. Reconstruction of mandibular defects is one of the most challenging operations that a surgeon can encounter because a satisfactory functional as well as a good aesthetic outcome must be concurrently achieved [6-9]. Tin et al. [10], submitted that surgeons have been trying to reconstruct the mandible for more than a century and despite the enormous progress made over the previous years, the ideal system for mandibular reconstruction has not been developed.

The size and complexity of the defect have been reported to influence the outcome of mandibular reconstructions by different authors [11-14] Jewer Jewer et al.'s Hemi-Mandibular-Central-Lateral (H-C-L) segmental mandibular defect classification system took cognizance of the complexity of the reconstruction rather than the size or anatomic location of the defect [15]. Arotiba et al. [15], proposed the La-Co-CE mandibular segmental defect classification system in order to better reflect the degree of surgical difficulty of the reconstruction; it was arranged in order of envisaged increasing difficulty of reconstruction with autogenous bone grafts into six major groups and 24 specific anatomic types [5]. This classification system recognizes 3 anatomic-surgical reconstructive zones of the mandible (Fig 1).

Rationale

Ameloblastoma is the most common odontogenic tumor in Black Africans [16]. It is reported to be more common in Black

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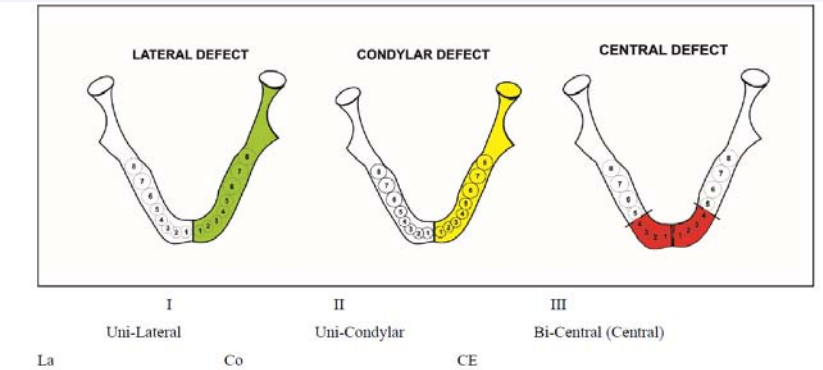

Figure 1 The three anatomic-surgical reconstructive zones of the mandible in the La-Co-CE defect classification system (Note that the symphysis is the anterior limit of both Uni-Lateral and Uni-Condylar defects).

Africans than Caucasians [17]. It is most commonly seen in the mandible (Figure 2). This aggressive but benign tumor is treated surgically like a malignancy by wide en-block resections of the mandible with severe compromise of facial aesthetics and oral functions if the mandible is left unreconstructed [18,19]. A clinical evaluation of the outcome of reconstruction of the mandible is of relevance to surgeons practicing in developing countries with poor access to advanced reconstructive technology (distraction osteogenesis and tissue engineering) available to other surgeons practicing in more advanced countries (UK, USA, Japan, Australia) [5].

OBJECTIVE

To evaluate the clinical outcome of mandibular segmental defect reconstructions using the La-Co-CE defect classification system following resection for benign tumours.

METHODOLOGY

Patients seen are those who had mandibular resection with reconstruction done due to benign tumors from January 2010 to December 2012 and were retrospectively reviewed between January 2015 and November 2016 (Ethics approval ref. No. LUTHREC ADM/DCST/HREC/APP/370). Patients with pre-existing bone pathology, craniofacial deformities and malignancies were excluded from this study. All resections and reconstruction was done under general anesthesia by the authors and outcome assessment was performed by a single separate surgeon. Outcome was assessed at a minimum of 12months after reconstruction was carried out.

Figure 2 Massive ameloblastoma of the mandible involving the symphysis bilaterally in a young Nigerian boy. The resection of this massive tumour will produce a combination Central defect.

The bio data of each patient (age, sex and occupation) was obtained. Other information obtained included was smoking habits, alcohol use and duration of symptoms. Post-operative information obtained included estimated length of defect (cm), estimated blood loss (ml), amount of blood transfused (pint), recipient site complications and final histopathology report.

The type of alloplastic material used (Titanium Reconstruction plate manufactured by Martin - Germany and TRIMED –Turkey) for reconstruction was noted as well as the timing of bone graft (immediate, delayed or none). Outcome was divided into three (3) different categories: restoration of jaw continuity and acceptable facial cosmesis, restoration of arch curvature and good occlusal relationship with the maxilla and maintenance of long term osseous bulk.

An informed consent was obtained from each patient for their inclusion in the surgical procedure and an approval for this study was obtained from the health research and ethics committee of the hospital. Data was recorded prospectively on proforma designed specifically for this study. Data was analysed using SPSS for windows (version 20.0; SPSS mc, Chicago. IL, USA) statistical software package; and presented in descriptive and tabular forms. Frequency distribution and cross tabulations to examine relationships between variables were done. The Fisher's exact test was used to compare differences between proportions and multiple linear regression analysis was done on the outcome variable (osseous bulk) to determine the predictors of osseous bulk. For all comparisons, $P < 0.05$ was adopted as the criterion for establishing a statistical significance.

RESULTS

Twenty-seven patients in total were enrolled for this study; there were 9 males (33.3%) and 18 females (66.6%). Age range

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was 17-65 years with a mean of 33.1 ± 10.9. Eighteen subjects (66.7%) had mandibular resection due to solid multicystic ameloblastoma, 2 subjects had unicystic ameloblastoma [5], subjects had keratocystic odontogenic tumor and 2 subjects had ossifying fibroma (Table 1).

The mean estimated blood loss was 809 ± 336 ml while the mean blood transfused was 1.2 pints. Only 5 (27.8%) of subjects had recipient site complications and the most common complication was infection (11.1%)-others included wound dehiscence (7.4%) and haematoma (3.7%).

Twenty six subjects had reconstruction with titanium reconstruction plate used as alloplast and only 1 had acrylic alloplastic reconstruction (Table 2). Nine (9) subjects had immediate reconstruction with iliac crest bone graft, 3 had delayed reconstruction with iliac crest bone graft while 15 are yet to have reconstruction done. Eleven (11) of the subjects who had iliac crest bone graft taken were from the anterior iliac crest while one (1) was taken from the posterior iliac crest.

Twelve subjects with titanium used as alloplast had good jaw and facial cosmesis (46%) while others (14 of titanium, 1 acrylic) had good jaw continuity but noticeable facial asymmetry (57.7%) – (Table 2). None of the patients with delayed reconstruction had good facial and jaw cosmesis while 8 of the immediate reconstruction and 4 of no bone graft had good facial and jaw cosmesis. This shows that immediate reconstruction had better jaw and facial cosmesis than delayed bone graft as this was statistically significant (p=0.004).

Fifteen (55.5%) of subjects who had titanium used as alloplast had good arch curvature and occlusion and the only subject who had acrylic reconstruction had a fair arch curvature and occlusion (Table 2). All the subjects (9) who had immediate bone graft reconstruction had good arch curvature and occlusion while one (1) of the delayed and 5 of the no bone graft had good arch curvature and occlusion. This also shows that immediate bone graft reconstruction produces better arch curvature and occlusion as this was statistically significant (p=0.002)

All the subjects (3) who had delayed reconstruction had good osseous bulk while 50% (3) of the immediate bone graft had good bulk while 50% had fair osseous bulk. This however was not statistically significant.

Multivariate regression analysis done to determine the predictors of outcome (osseous bulk) using dependent variables: age, smoking history, timing of bone graft, and estimated length of defect, estimated blood loss and amount of blood transfused; shows that only timing of bone graft and estimated length of defect are significant predictors of osseous bulk while others are not significant (Table 3).

Based on classification of the defects, the condylardefect is the most involved segment of the mandible (9 of 27 patients) followed by Central-Lateral (CE-La) defects. In assessing aesthetic outcome based on defects, the lateral defects alone has good jaw continuity and facial cosmesis in all subjects seen in this study whereas most subjects with condylar and central defects have good jaw continuity but noticeable facial asymmetry (Table 4). This shows that central and condylar defects are more difficult to reconstruct and this is statistically significant in our study (*p*

Table 1: showing demographics of subjects, blood loss and blood transfused.

		Frequency (%)	Range	Mean	Std Deviation
Age			17-65	33.1	10.95
Gender	Male Female	9 (33.3) 18 (66.7)			
Diagnosis	Multicysic ameloblastoma Unicystic ameloblastoma Keratocyst Ossifying fibroma	18 (66.7) 2 (7.4) 5 (18.5) 2 (7.4)			
Blood loss			250-1400mls	809.2	336.2
Blood transfused			0-3 pints	1.2	

Table 2: outcome variables compared with osseous reconstruction done (immediate, delayed or none).

OUTCOME		Immediate	Delayed	None	Total	p-value
Restoration of jaw continuity and cosmesis*	Good jaw continuity and facial cosmesis	8	0	4	12	0.004
	Good jaw continuity and noticeable facial asymmetry	1	3	11	15	
Restoration of arch curvature and occlusion**	Good	9	1	5	15	0.002
	Fair	0	2	10	12	
Long term maintenance of osseous bulk ***	Good	5	3	0	8	0.49
	Fair	4	0	0	4	

* – Clinical as well as radiological evidence of rigid bony union with no gross facial asymmetry
** – No arch/occlusal discrepancies between the maxilla and mandible
***– More than 70% of initial grated bone height and width is maintained 12-24 months postoperatively

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= 0.006).

DISCUSSION

The mandible is regarded as both functionally and cosmetically one of the most important structures of the head and neck, contributing to contour of the face, mastication, speech and deglutition (16). The mandible also plays a major role in protecting the airway and support of both hard and soft tissues found in the oral cavity including the tongue, lower dentition, and the muscles of the floor of the mouth permitting mastication, articulation, deglutition, and respiration [1,16]. The most common indication for mandibular reconstruction has mostly been reported as ablative surgery for neoplastic lesions (benign or malignant) of the oral cavity [17]. Some other causes of mandibular defects include trauma, infection/inflammation, osteoradionecrosis, and congenital deformities [15,18].

The reconstruction of mandibular continuity defects still remains a daunting task in reconstructive facial surgery.[19] This is due to the complex nature of the mandibular anatomy which is a U-shaped bone with articulations with the temporo-mandibular joint (TMJ). The mandible also has different curves on its anatomy making it very difficult to replicate [20,21].

Techniques utilizing metal reconstruction plates, free autogenous bone grafts, heterografts, xenografts, and bone substitutes have been utilized, and still remain viable options [22]. Although there have been many developments and improvements in these techniques, autogenous bone grafting currently produces the best results. Bones such as the calvarium, ribs, iliac bone, tibia, radius, and scapula have been regarded as suitable candidates for donor sites [18,23].

Table 3: Multivariate regression analysis showing the predictors of osseous bulk.

Dependent variable	P value
Smoking history	0.41
Age	0.11
Timing of bone graft	0.001
Estimated length of defect	0.019
Estimated blood loss	0.209
Blood transfused	0.285

Table 4: relationship between classification of mandibular defects and aesthetic outcome.

Defect classification	Restoration of good jaw cosmesis and facial cosmesis	Restoration of good jaw continuity and noticeable facial asymmetry	Total
Uni-Lateral	5	0	5
Uni-Condylar	2	7	9
Isolated Central	1	4	5
Combination Cental	4	4	8
Total	12	15	27
P=0.006			

However, a number of problems have been encountered with autogenous bone grafting in cases with compromised blood supply resulting from radiation therapy or in cases with extensive defects, which include complications such as infection and graft resorption [17]. Vascularized bone grafts have become an indispensable modality to avoid such problems, and have shown favorable results in terms of healing [18]. Vascularized bone graft also has its own drawback in that it is very expensive especially in resource-challenged environments and time-consuming [24].

Drawbacks of non-vascularized bone graft include donor site complications, failure of the bone graft and inability to tolerate radiation. However, in this study all cases are benign neoplasms thus fewer complications were noticed. Non-vascularized bone graft has been reported to create a better contour and bone volume for implant insertion and aesthetics [26, 27].

The major limitation of the La-Co-CE system is its numerous specific defect types (24). Because of this it's practical clinical uses are limited as its evaluation will be cumbersome because it will be difficult to get enough cases allocated to each specific anatomic defect type. Therefore, the 6 groups of defect types have more practical clinico-surgical applications. In this study we have further reduced the groups to 5 (Simplified La-Co- CE system) as follows;

i. Unilateral segmental mandibular defects from sympysis menti to ramus with preservation of the condyle (Uni-Lateral defect; La).

ii. Unilateral segmental defects with sacrifice of one condyle (Uni-Condylar defects; Co)

iii. Isolated Central defect (mental foramen to mental foramen; CE)

iv. Combination Central-Uni-Lateral (CE-La) and Central-Uni-Condylar (CE-Co) defects

v. Combination Central-Bi-lateral (La-CE-La) and Central-Bi-Condylar (Co-CE-Co) defects (Total mandibulectomy)

Combination central defects are the most challenging to reconstruct for the following reasons:

a. The defects involve complete sacrifice of the symphysial region. In this area of the mandible, apart from the complex anatomy (super imposed parabolic curves of the basal bone and the alveolar bone), there are powerful muscle insertions (mentalis, genioglossus and geniohyoid).

b. The alveolar mucosa is thin, friable and of limited width in comparison with the thick and more abundant soft tissues of the horizontal ramus (body).

c. It is more challenging to reproduce the super imposed parabolic curves of the basal bone and the alveolar bone.

d. Combination defects are usually of very extensive span.

For practical surgical reconstructive difficulty evaluation, combination defects could be compressed into one and this was what we did in this study. In the final analysis therefore, we had only 4 groups- Uni-Lateral (I), Uni-Condylar (II), Isolated Central (III) and Combination Central (IV) defects.

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This study reports no unsuccessful bone graft but a partial loss of graft in 33% of all cases-both immediate and delayed (44.4% of immediate and 0% of delayed had partial loss).This agrees with the report by Ogunlade et al., [28]. However, Szpindor [29], reported that about 50% of non-vascularized bone graft resorbed after 24 months follow up. This difference may be accounted for by the improvements in techniques of harvesting, management and placement of graft and all patients reviewed in our report had benign lesions. A comparison of non-vascularized bone graft and vascularized bone graft by Foster et al. [26], reported 69% maintenance of volume in non-vascularized graft and 96% with vascularized bone graft. This was statistically significant and they recommended that non-vascularized bone graft should be restricted to defects < 6cm with no prospects of radiotherapy.

There are many factors associated with the long term maintenance of osseous bulk: age of patient, radiotherapy or diagnosis of malignant disease, blood loss during procedure and length of defect [18,25,28]. Only length of defect and timing of reconstruction (immediate or delayed) were significant predictors of long term maintenance of osseous bulk in this study. Delayed reconstruction has been associated with lower complications with better maintenance of osseous bulk [25] (Figure 3 and Figure 4).

Reconstruction of the condyle is necessary to restore facial height, maintain inter-incisal distance and prevent deviation during movement. Condylar defects especially those also involving the ramus and body of mandible are reported as most difficult to reconstruct [19,21,23], which is in agreement with this study. This is because the condylar bulk and form needs to be reconstructed and positioned within the Temporo mandibular joint fossa and surrounding pterygoid muscles. When it involves other parts of the mandible, replicating the various curvatures of the mandible as well as maintaining good occlusal relationship with the upper jaw can be very challenging [30,31].

Figure 3 Long term maintenance of osseous bulk following delayed reconstruction (Uni-Lateral-La defect) using intra-osseous wiring (and initial fixation with arch bar / Kirshner wire).

Figure 4 Good maintenance of osseous bulk following delayed iliac crest reconstruction of a combination Bi-Central-Unilateral defect (CE-La).

CONCLUSION

With improved techniques, non-vascularized iliac crest bone graft remains a viable option for reconstruction of the mandible following resection for benign tumors; particularly in resource-challenged environments. Classification of the envisaged surgical reconstructive difficulty using the La-Co-CE segmental defect classification system enables evaluation of the outcome and permits objective comparisons of reports in the literature.

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