Individualized reconstruction of major mandibular defect based on craniomaxillofacial correlationship

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Purpose: To find a solution for individualized contour reconstruction of severe mandibular defect based on craniomaxillofacial correlationship.

Materials and Methods: Total 10 adults with normal occlusion were included in this study. After cephalometric analysis, accuracy of regression equations of mandibular contour variables from our previous series studies on mandibular contour correlation was testified by statistical analysis. Meanwhile, the data of mandibular contour variables and lateral inferior arc curve of mandible were supplied for one patient with severe mandibular defect for individualized reconstruction.

Results: No statistical difference ($p>0.05$) was presented between the values of mandibular contour variables from two different methods (actual measurements and mathematical calculations). Moreover, aesthetic profile was obtained postoperatively in this clinical case.

Conclusion: Analysis of mandibular contour correlation could provide very important data for individualized reconstruction of severe mandibular defect. **(Int Chin J Dent 2003; 3: 45-52.)**

Clinical Significance: Correlation study of mandibular contour versus three dimentional cranio-maxillofacial structures provided a beneficial exploration for individualized reconstruction of severe mandibular defect with loss of primary position.

Key Words: Contour, Correlation, Mandible, Reconstruction.

Introduction

To date free vascularized autogenous bone graft is still the main and optimal method for reconstruction of mandibular defect. Oral maxillofacial surgeons are often challenaged by accurately positioning and shaping the neomandible for those with cross-midline major mandibular defects due to loss of primary anatomic position. After performing a series of basic studies on mandibular contour correlation versus three dimentional craniomaxillofacial structures, we found that there existed significant quantitative correlationship between mandibular contour, determined by ArGo, GoPg, GoGo, and craniomaxillofacial structures.[1] The aim of this paper was to verify the reliability and practicability of previous conclusions. Meanwhile, combined with a typical case, a new method of mandibular contour reconstruction was introduced in details.

Materials and Methods

Total 10 Han tribe adults (>18 years) with normal occlusion from East-China were included in this study. Of them, five were male and five were female respectively. The mean age was 41.1 years. The criteria of normal occlusion was characterized by neutral occlusion, normal range of over bite and over jet, without dental displacement and history of orthodontic and orthognathic treatment. All subjects took biplanar (lateral and frontal view) cephaloradiography (Figs. 1 and 2) followed by cephalometric analysis. Good exposure and clear appearance in every X-ray film were guaranteed.

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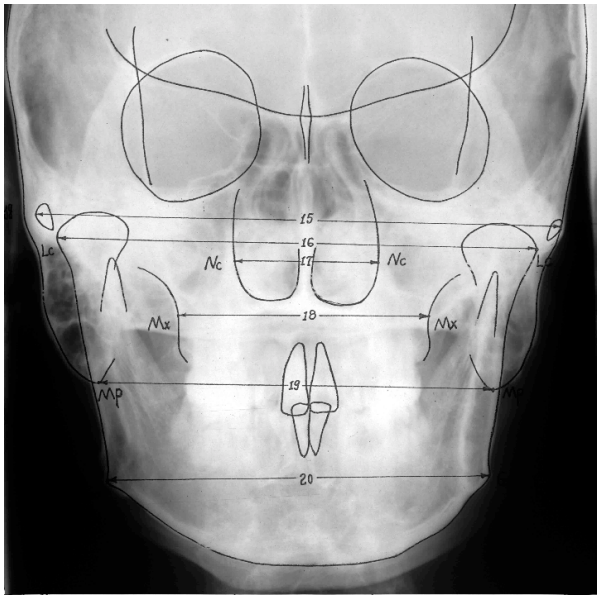

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Fig. 1. Markers and linear parameters in lateral cephalometric tracing. 2 (Ba-A) represents projecting distance between Ba point and A point on Frankfort plane; 3 (Ba-Ar) represents projecting distance between Ba point and Ar point on Frankfort plane; 6 (Ptm-A) represents projecting distance between Ptm point and A point on Frankfort plane; 7 (Ba-S) represents projecting distance between Ba point and S point on Frankfort plane; 10 (N-A) represents projecting distance between N point and A point on the plane vertical to Frankfort plane; 11 (Ba-S(H)) represents projecting distance between Ba point and S point on the plane vertical to Frankfort plane; 13 (Ar-Go) represents distance between Ar point and Go point; 14 (Go-Pg) represents distance between Ar point and Go point.

Fig. 2. Markers and linear parameters in frontal cephalometric tracing. 15 Zyg (L,R) represents distance between bilateral Zyg points; 16 Lc (L,R) represents distance between bilateral Lc points; 18 Mx (L,R) represents distance between bilateral Mx points; 20 Go (L,R) represents distance between bilateral Go points.

According to the results of correlation study of mandibular contour, we measured various linear variables directly on tracing-paper in terms of different genders as follow: ArGo, GoPg, GoGo, MxMx, BaA, ZygZyg for male, ArGo, GoPg, GoGo, NA, PtmA, BaA, ZygZyg, BaS, BaS(H), BaAr, LcLc for female. Upon regression equations of mandibular contour[1] (Tables 1 and 2), calculated values of mandibular

contour variables (ArGo, GoPg, GoGo), which were compared to the actual measured values of mandibular contour variables directly from radiography by the paired t-test procedure of SAS (version 6.12), were obtained to testify the reliability and feasibility of equations.

Results

Tables 1 through 4 show the analysis results.

Table 1. Results of regression analysis between mandibular contour variables and craniomaxillofacial parameters in females.

Parameters	Intercepts	NA	PtmA	BaA	ZygZgy	BaS	BaS(H)	BaAr	LcLc	P-values
ArGo	0.0166	0.5674	0.7006				-0.5624			0.0002
GoPg	1.9716			0.7012	-0.4249			-0.9245	0.4465	0.0001
GoGo	1.0581				0.7575	-0.6556				0.0001

Table 2. Results of regression analysis between mandibular contour variables and craniomaxillofacial parameters in males.

Parameters	Intercepts	MxMx	BaA	ZygZyg	P-values
ArGo	1.2434	0.5829			0.0023
GoPg	3.1561		0.4956		0.0011
GoGo	-2.8837	0.7657		0.5801	0.0001

Above two tables from Xu L, Zhang C, et al. A study on correlation of mandibular contour. Shanghai Second Medical University Academic Dissertation for Master Degree, 2002: 17-31.[1]

No statistical difference was presented between the calculated values of mandibular contour variables and that of measured values, $p>0.05$ (Tables 3 and 4).

Case Report

A female patient, 52-year-old, from Fujian province of East-China was admitted to oral maxillofacial department of Shanghai Ninth People's Hospital. Seven years ago, she underwent radical oncological ablation due to suffering rhabdomyosarcoma of floor of mouth. After surgery, major mandibular defect almost from angle to angle contributing to impairment of oral function and lower facial contour developed, when she consulted our department (Figs. 3 and 4). From radiographical appearance, the stumps of mandible were displaced anteriorly, internally and upward due to uncontinuity of the mandible, the primary position of pogonion and gonion was lost (Figs. 5 and 6). Consequently, how to restore the contour and position of neomandible was the key to functional reconstruction.

Table 3. The calculated values and actual measured values of mandibular contour variables (cm).

No.	Ar-Go		Go-Pg		Go-Go	
	Calculated	Measured	Calculated	Measured	Calculated	Measured
1	5.2	5.5	8.2	7.8	9.9	9.6
2	5.1	5.4	8.3	9.0	10.0	10.5
3	4.7	5.0	7.9	7.5	9.8	10.1
4	4.3	4.4	7.2	7.0	9.7	9.6
5	4.7	4.3	7.9	8.1	10.1	10.1
6	5.7	6.5	8.1	8.1	11.9	11.8
7	5.3	5.5	8.2	8.9	11.4	12.2
8	5.2	5.0	8.0	7.8	10.9	12.1
9	5.4	5.7	7.6	8.4	10.7	11.0
10	5.1	5.2	7.7	8.0	10.6	9.2

Table 4. The paired t-test results of calculated values and actual measured values of mandibular contour variables.

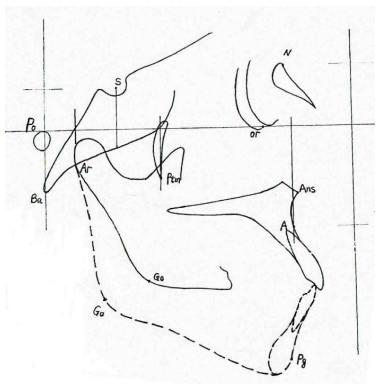
Contour variables	Mean	s	t	p
ArGo	-0.1800	0.3225	-1.7650	0.1114
GoPg	-0.15	0.4625	-1.0256	0.3318
GoGo	-0.1200	0.7021	-0.5405	0.6020

3 4 5

Figs. 3-5. Preoperative frontal view, right lateral view, and frontal cephalometric film.

As usual, biplanar cephalometric radiography was taken for this patient followed by cephalometric analysis (Figs. 7 and 8). The value of preserved ramus ArGo was equal to 5.1 cm. Other variables values included NA=6.4 cm, PtmA=5.1 cm, BaS(H)=3.7 cm, BaA=9.35 cm, ZygZyg=13.25 cm, BaAr=1.2 cm,

LcLc=12.15 cm, BaS=2.6 cm, which were input into the regression equations, achieving the calculated values of mandibular contour variables ArGo=5.1401 cm, GoPg=7.2135 cm, GoGo=9.3904 cm.



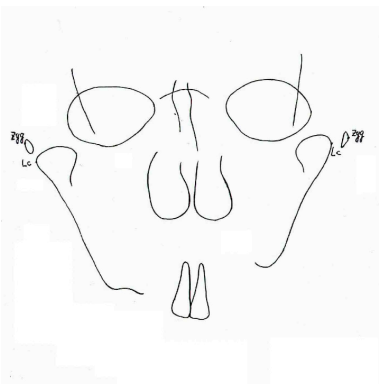


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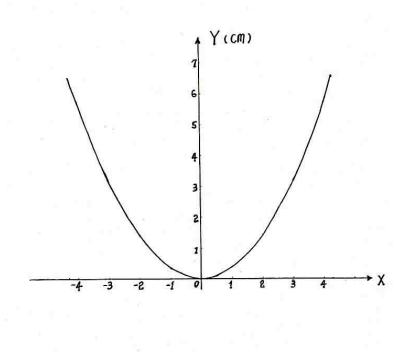
Fig. 6. Preoperative lateral cephalometric film showed anterior, internal and upward rotation of the residual ramus.
Fig. 7. Markers and parameters in lateral cephalometric tracing-paper. The dotted line was simulation of neomandibular profile based on the data of calculated mandibular contour variables.
Fig. 8. Markers and parameters in frontal cephalometric tracing-paper.

Similar to orthognathic surgery, template surgery was performed depending on the data of mandibular contour variables. We simulated mandibular reconstruction and got a satisfied profile on lateral cephalometric tracing-paper (dotted line in Fig. 7). Mandibular contour was composed of posterior border of ramus (ArGo) and the lateral inferior arc curve of mandibular body. According to our studies on dry mandibular samples of adults from East-China, the lateral inferior arc curve, determined by GoPg, GoGo, was a piece of parabola which passed pogonion as origin and was symmetric against centric sagittal axis ($Y=KX^2$, $p<0.01$). Consequently, we could obtain the mathematical model of the lateral inferior arc curve ($Y=0.3585X^2$) depending on the data of mandibular contour variables and drew this curve at the ratio of 1:1 to guide fabrication of template of lateral inferior arc curve (Figs. 9 and 10). In addition, the amount of transplanted free fibula flap (15.4 cm) was predicted. During the operation, we could position and shape the neomandible upon template with less time (Figs. 11and 12). Postoperatively, satisfactory contour was obtained (Figs. 13-15).

Discussion

Many authors had developed a variety of techniques for restoration the primary mandibular contour. There were about three methods in summary: (1) Precontour reconstruction plate technique,[2] which could be used to record and keep the primary position of mandibular stumps after mandiblectomy, guided shaping the neomandible, but this technique was only indicated for those without destruction or erosion of buccal cortical bone. (2) Surgical template techniques, which could be subdivided into two types. Indirect method was that template was made depending on the preoperative lateral cephaloradiography and CT scan, and

modified in reference to the measurements of mandibular specimen in the course of operation.[3] Direct method was that prothesis was obtained preoperatively by intraoral surgical stents.[4]



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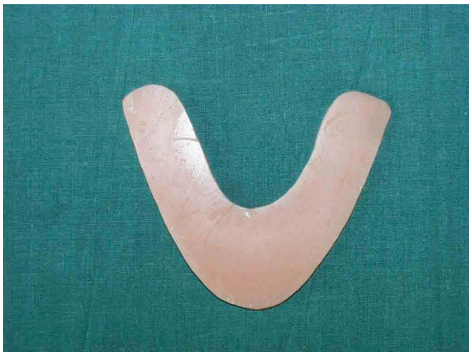

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Fig. 9. The parabola of lateral inferior arc curve (1:1).
Fig. 10. The guided template of lateral inferior arc curve.

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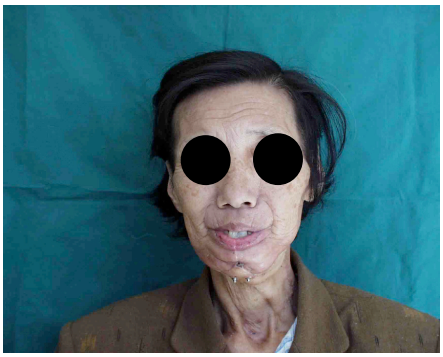

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Fig. 11. The volume prediction of the vascularized fibular flap.
Fig. 12. The prefabrication of the reconstructive titanium plate and fibular osteotomy.
Fig. 13. Postoperative frontal picture.

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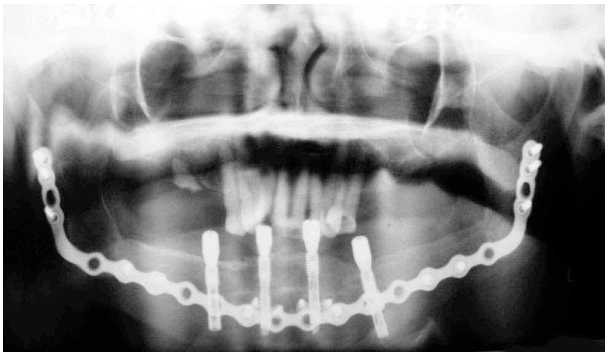

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Figs. 14-15. Postoperative right lateral picture and postoperative panoramic view.

However, surgical template techniques were indicated for those without high need for rehabilitation of

occlusion relationship such as endentulous patients. (3) Splint and plate technique, by which primary position of mandibular stumps was fixed to maxillary splint. Meanwhile, gonion or pogonion could be marked by titanium plate extended from splint.[5] This technique was adopted in the situations where the above two techniques were unsuitable. But application of these techniques had a prerequisite that there should exist primary mandible without displacement of mandibular position before mandibular reconstruction. In the situations where primary mandibular position lost such as secondary major mandibular defect even total mandibular defect or mandibular contour had severe destruction, it was tremendous challenge for reconstructive surgeon to restore the position and contour of neomandible.

Usually upon maxillary dental arc and clinical experience, bone graft could be shaped to match maxilla. Obviously, this technique was inaccurate and time-consuming. According to two Chinese reports,[6,7] the lateral inferior arc curve of mandible and lateral superior arc curve were two complete different parabola ($p<0.05$), so shaping neomandible by maxillary dental arc was unreasonable and often brought about secondary deformity such as retrognathic abnormality or neomandibular angles eversion. Meanwhile, previous study confirmed that mandibular contour had individual characteristics,[8] also it was not proper to use normal mean values of mandible replacing that of individual mandible contour variables.

Quantitative correlationship between mandibular contour and craniomaxillofacial structures had been established according to the consistent principle of mandible-craniomaxillary structures.[9] We could predict mandibular contour by three dimensional craniomaxillary structures. It was a worthy trial for individualized reconstruction of major mandibular defect. In addition, to warrant the success of complex operation and to decrease statistical error as possible as we could, simulation surgery was performed as orthognathic surgery to testify the data of mandibular contour variables.

Conclusion

In conclusion, it was feasible for clinical application of mandibular contour correlationship by provement of this study, but there existed difference in aspects of tribes and areas, further correlation study of mandibular contour was necessary.

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