Title: **Convex Bone Deformity after Closed Reduction of Nasal Bone Fracture**

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Summary

Background: Nasal fractures are the most common type of facial fracture treated by plastic surgeons. Here, we clarify the postoperative deformities that frequently remain after closed reduction of fresh nasal bone fracture by three-dimensional computed tomography (3D-CT).

Methods: A total of 100 consecutive cases of fresh nasal bone fracture in patients treated between May 2010 and January 2016 were examined. After closed reduction, the overall appearance of the arch formed by the nasal bone and maxillary process was evaluated as “Excellent”, “Good”, or “Fair”. Patients were also asked about their overall satisfaction with the operation, and the responses were classified as “Satisfied”, “Neutral”, or “Dissatisfied”.

Results: Eighty-six patients underwent 3D-CT examination both at the time of the initial consultation and 3 months after the operation. The results were “Excellent” in 69 patients and “Good” in 17 patients, with none of the patients having only “Fair” results. Convex bone deformities on one side were seen in all six bilateral type fractures evaluated as “Good”. All patients classified as “Excellent” reported being “Satisfied” with the results, but some patients classified as “Good” gave a ”Neutral” evaluation regarding their satisfaction.

Conclusions: The residual deformities seen in bilateral type fractures were most notable, and they were all convex bone deformities on one side. Plastic surgeons should use ultrasonography or other reliable new methods in addition to visual inspection during the operation to successfully treat the region of the convex fracture.

Key Words: nasal fracture; secondary nasal deformity; convex bone deformity; bilateral fracture type; facial bone fracture

Introduction

Nasal fractures are the most common type of facial fracture treated by plastic surgeons[1]. The operations are simple, and postoperative evaluations are seldom performed. There have been few reports regarding evaluation of secondary nasal deformities after treating fresh nasal bone fractures. In the present study, we used three-dimensional computed tomography (3D-CT) to examine both the preoperative and postoperative shapes of the nasal fractures to clarify the postoperative deformities that frequently remain after closed reduction of fresh nasal bone fractures.

Methods

A total of 100 consecutive cases of fresh nasal bone fractures in patients that visited our hospital between May 2010 and January 2016 (70 males, 30 females; age range, 2 – 87 years) were examined. Cases were classified into four types of fracture: unilateral, bilateral, frontal and frontal/lateral mixed [2)3)4)] (Fig. 1). This study was performed in accordance with the "*Strengthening the Reporting of Observational Studies in Epidemiology*" guidelines. The study protocol was reviewed and approved by our local institutional review board.

Closed reduction was performed under general anaesthesia in all patients.

Depressed bone fractures were manipulated outward and convex bone fractures were manipulated inward[5]. Internal fixation was performed with nasal packing and external fixation was performed with a metallic splint. Internal fixation was removed 1 week after the operation, and external fixation was fitted throughout the day for 2 weeks after the operation.

The cases were classified by measuring the angle (θ) between the nasal bone and the maxillary bone on postoperative 3D-CT (Fig. 2). Angles close to 0° were considered to indicate good reduction. The overall appearances of the arch formed by the nasal bone and maxillary process were also classified on a three-point scale [4)6)]. Angle measurement and scoring were performed by three plastic surgeons that were not involved in the operation. The average values of the angle measurement and the scoring were recorded.

A score of "Excellent" was given if the angle of the fractured portion was $< 10°$, there was no gap in the fractured portion and the arch had a smooth shape. A score of "Good" was given when there was a clear gap in the fractured portion or the shape of the arch was rough. The appearance was classified as "Fair" if the surgeon determined that reoperation was necessary. Convex bone deformity or depressed bone deformity was determined in cases in which the angle of the fractured portion was $> 10°$ (Fig. 3).

Three months after the operation, the patients were also asked to score their

overall satisfaction on a three-point scale: “Satisfied”, “Neutral” or “Dissatisfied”.

Results

3D-CT examinations were performed at the initial consultation and 3 months after the operation in 86 of 100 patients. These 86 patients wished to undergo 3D-CT to check their postoperative results regardless of satisfaction. We checked the postoperative results by visual inspection in the remaining 14 patients that were satisfied with the results and did not elect to undergo 3D-CT. The fractures consisted of bilateral type ($n=45$), unilateral type ($n=8$), frontal type ($n=12$) and frontal/lateral mixed type ($n=21$) (Fig.4). “Excellent” results were obtained in 69 patients and “Good” results were obtained in 17 patients, with none of the patients showing “Fair” results. “Good” results were found in six bilateral type fractures, no unilateral type fractures, one frontal type fracture and 10 frontal/lateral mixed type fractures (Fig. 5). Convex bone deformities on one side were seen in all six bilateral type fractures evaluated as “Good”. Of the 10 frontal/lateral mixed type fractures evaluated as “Good,” convex bone deformities were seen in seven cases, depressed bone deformities were seen in six cases and frontal fractured deformities were seen in two cases (Fig. 6).

Ninety-one patients reported that they were “Satisfied” with the postoperative results, nine patients were Neutral” and none of the patients were “Dissatisfied”. For the

cases classified as “Excellent” in all the types of fracture, all of the patients were “Satisfied” with the results. Some patients with “Good” evaluation reported being “Satisfied” with the results, but four patients with bilateral type fractures and five with frontal/lateral mixed type fractures classified as “Good” gave a “Neutral” evaluation (Fig. 7).

Discussion

Nasal bone fracture is the most common type of facial fracture encountered in our daily clinical consultation. Under closed reduction, it is not possible to visualise the fractured bone segment directly, and many surgeons may feel uneasy about whether adequate reduction has been achieved following treatment, which has may have consequences for postoperative external nose deformity.

There have been many reports regarding the incidence of post-reduction nasal deformities[7)8)9)]. Watson et al. reported a secondary nasal deformity incidence rate of 29% – 50%[7)]. Waldron et al. performed a prospective study of 100 patients, and reported a post-reduction deformity incidence rate of 14% – 15%[8)]. In a prospective study of 756 patients, Murray et al. reported an incidence rate of 41% for post-reduction deformity[9)]. There have been many reports regarding the incidence of post-reduction nasal deformities, but there

have been few detailed analyses regarding the types of nasal fracture. Many reports indicated that frontal/lateral mixed fractured type was difficult to manipulate. Motomura et al. reported a 56% incidence of secondary nasal deformity in frontal/lateral mixed fractured type, which was much higher than the rates for other types of fracture[6].

Our results showed an incidence rate of 19% (17 of 86 patients) for secondary nasal deformity. Although this incidence seems slightly high, we used 3D-CT to evaluate nasal deformity, which is more accurate than the methods used in previous studies. We obtained good results for the frontal fracture type compared to the other types, and deformities were mostly seen in the frontal/lateral mixed fracture type. These observations were consistent with previous reports. The residual deformities seen in bilateral type fractures were most notable, and all were unilateral convex bone deformities. Surprisingly, there were no cases of depressed bone deformity. These observations suggested that pushing down the convex bone part is probably more difficult than elevating the depressed bone part. In addition, there were more cases of convex bone deformity than depressed bone deformity in the frontal/lateral mixed fracture type.

It is important to evaluate the results postoperatively as in other types of fracture. CT is much more reliable than plain film as used previously for diagnosis and evaluation of nasal fracture[2)10)]. In addition, 3D-CT provides high spatial resolution[11)]. Using 3D-CT,

operations can be evaluated from another point of view and this experience can be applied in future cases[6)12)]. However, there may be some concerns about the risks associated with radiation exposure in repeated CT scans 3 months after surgery[13)14)15)]. There have been some reports regarding use of ultrasonography in cases of nasal fracture for intraoperative and postoperative assessment of surgical outcomes[16)17)18)19)]. Intraoperative ultrasonography allows visualisation of local and superficial fractures of the nasal bone and it may be useful for manipulating convex bone fractures, which is much more difficult than manipulating regions of depressed bone. Surgeons should not depend on ultrasonography alone, but it should be used in addition to visual inspection during the operation. 3D-CT 3 months after surgery is necessary especially in patients requiring reoperation. However, for patients that are satisfied with the results, ultrasonography may be used as an alternative to evaluate the postoperative results.

The evaluation of postoperative results on 3D-CT corresponds to patient satisfaction. All of the patients evaluated as “Excellent” for all types of fracture were satisfied with the results, but some patients classified as “Good” gave a “Neutral” evaluation; these latter patients all complained about the residual convex bone deformity, which they could feel from the surface of the skin. Although we explained the possibility of reoperation by osteotomy to treat the convex bone part, all of these patients refused to

undergo another operation. Thus, surgeons should treat the nasal fracture in the first single operation by closed reduction.

Conclusions

The results presented here indicated that it is possible to treat frontal fracture type, most cases of uncomplicated frontal/lateral mixed fracture type, and the depressed fractured part of the bilateral/unilateral fractured type by closed reduction. It is difficult to manipulate the convex fractured part. Most patients were satisfied with the operation results, but some complained about the convex bone deformity. Plastic surgeons should use ultrasonography or other reliable new methods in addition to visual inspection during the operation to successfully treat the convex fractured part in the first single operation by closed reduction.

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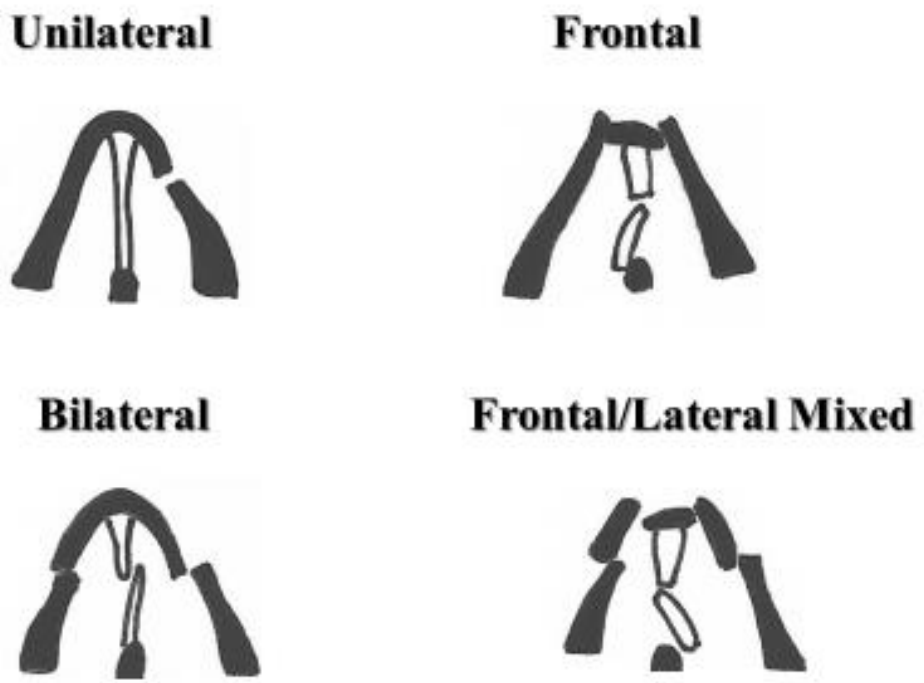


Fig. 1. Four types of fracture

Fig. 2. Schematic and 3D-CT of a nasal bone fracture. The angle (θ) between the nasal bone and the maxillary bone was used for postoperative evaluation.

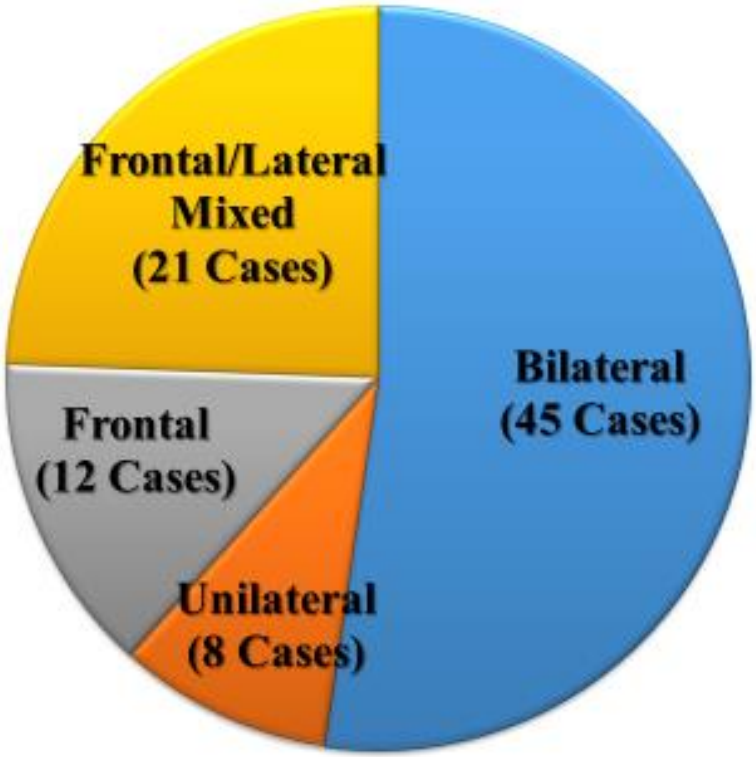


Fig. 4. Numbers of cases of the four types of fracture.
3D-CT examinations were performed at the initial consultation and 3 months after the operation in 86 cases.

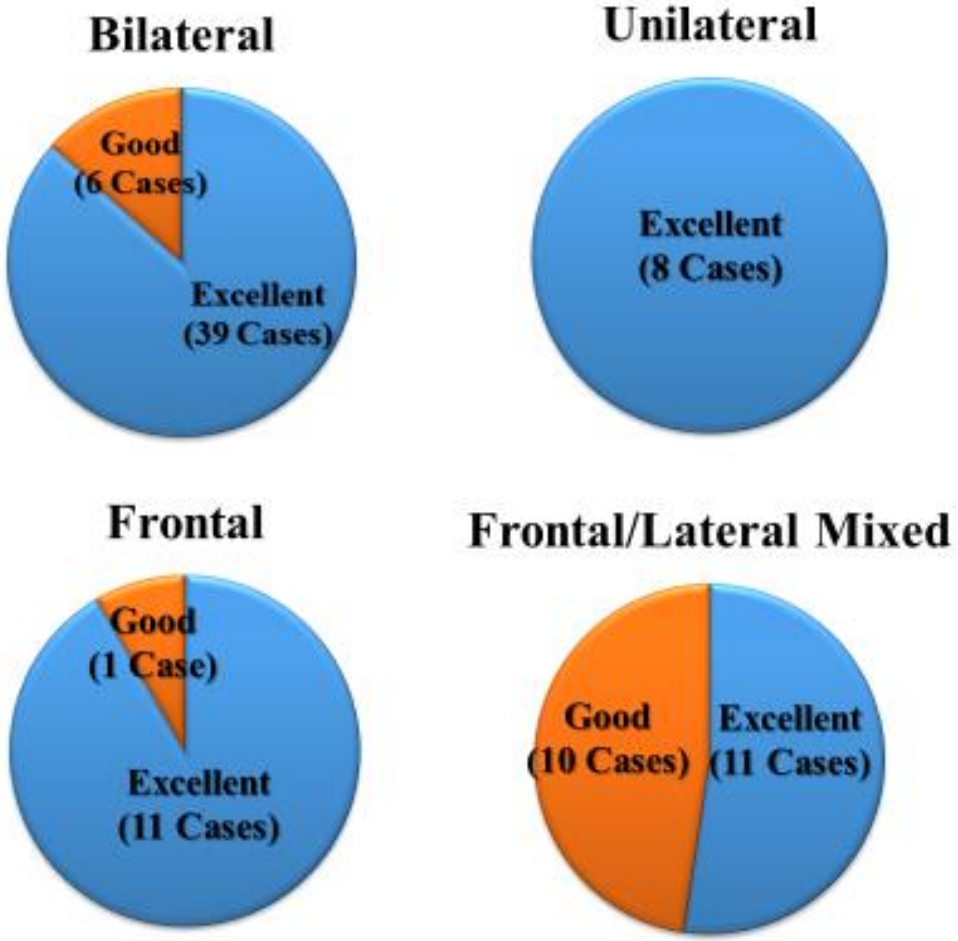


Fig. 5. Grading of four types of fracture

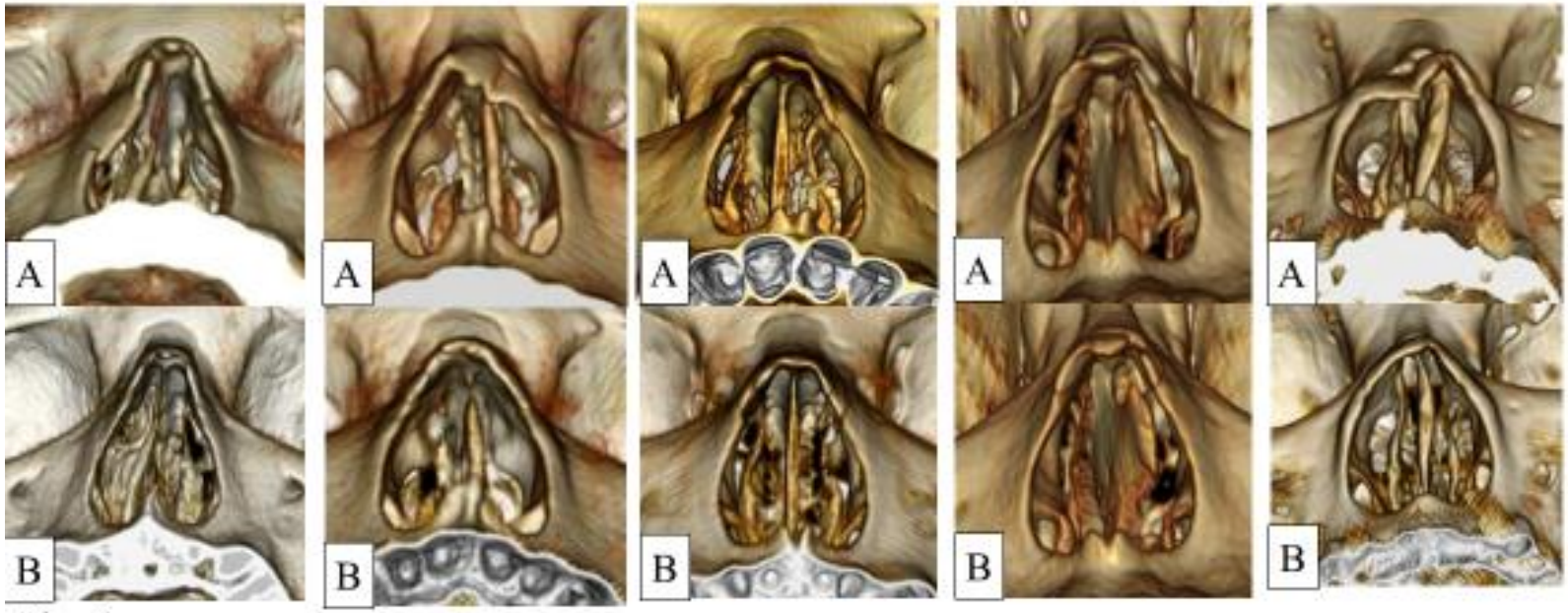


Fig. 6.

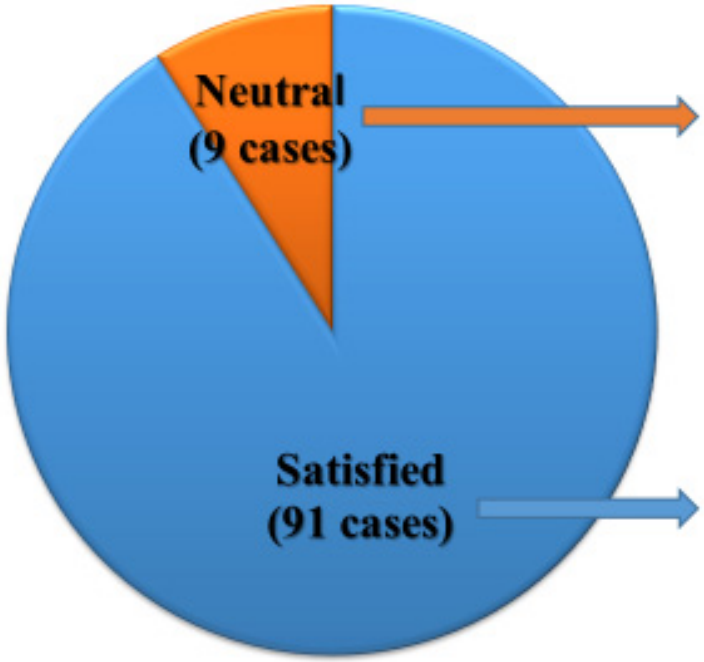
a) Bilateral case. (A) Preoperative 3D-CT findings. (B) 3D-CT findings 3 months after surgery. Evaluation: Excellent.

b) Frontal/Lateral mixed case. (A) Preoperative 3D-CT findings. (B) 3D-CT findings 3 months after surgery. Evaluation: Excellent.

c) Bilateral case. (A) Preoperative 3D-CT findings. (B) 3D-CT findings 3 months after surgery. Extruded bone deformity was observed on the right side. Evaluation: Good.

d) Bilateral case. (A) Preoperative 3D-CT findings. (B) 3D-CT findings 3 months after surgery. Extruded bone deformity was observed on the right side. Evaluation: Good.

e) Frontal/Lateral mixed case. (A) Preoperative 3D-CT findings. (B) 3D-CT findings 3 months after surgery. Extruded bone deformity was observed on the left side. Evaluation: Good.



	Excellent	Good
Bilateral	0	4
Unilateral	0	0
Frontal	0	0
Frontal/Lateral Mixed	0	5

	Excellent	Good
Bilateral	39	2
Unilateral	8	0
Frontal	11	1
Frontal/Lateral Mixed	11	5

Fig. 7. Grading of patient satisfaction

The total number of cases was 100. The 14 cases in which patients were satisfied with the results and did not wish to undergo 3D-CT 3 months after the operation were included in the "Satisfied" group.