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CLINICAL RECORD

Morphological consequences of lateral outfracture of the inferior turbinate

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Abstract
Objective: We report three cases of lateral outfracture of the inferior turbinate, which demonstrate a range of changes in the size, position and shape of the inferior turbinate.

Method: During a study of the validity of computer modelling of nasal airflow, computed tomography scans of the noses of patients who had undergone lateral outfracture of the inferior turbinate were collected. The pre-operative scan was compared with the post-operative scan six weeks later.

Results: In one patient, there was only a small lateral displacement of the inferior turbinate. In the other two cases, appreciable reduction in the volume of one inferior turbinate was noted, in addition to minor changes in the shape.

Conclusion: Lateral outfracture of the inferior turbinate produces varied and inconsistent changes in morphology which may affect the shape, size and position of the turbinate.

Key words: Turbinates; Hypertrophy; Otorhinolaryngologic Surgical Procedures; Complications; Anatomy; Tomography, X-ray computed

Introduction
Lateral outfracture of the inferior turbinate is advocated due to technical ease of performance and minimal associated surgical risk. As a singular procedure, only minor, temporary improvement is attained, reputedly due to the turbinate springing back to its original position.[1] However, the improvement resulting from other procedures, such as submucosal resection, can be enhanced with the addition of lateral outfracture.[2]

Two previous studies have reported measurements of the degree of lateralisation of the inferior turbinate bone after outfracture, obtained from computed tomography (CT) scans. Buyuklu *et al.*[3] performed CT scanning in 10 patients before and 9 months after lateral outfracture. Aksoy *et al.*[4] undertook CT scanning in 40 patients prior to turbinate outfracture and then 1 and 6 months later. However, the measurements reported by these two studies extended from the lateral side of the inferior turbinate bone to the lateral nasal wall, and were therefore more indicative of narrowing of the inferior meatus, rather than change in the diameter of the inferior nasal airway between the medial border of the inferior turbinate and the nasal septum. Neither study reported on changes in the soft tissue bulk and shape. Although these studies demonstrated that the inferior turbinate bone did not spring back into its original position, they did not comment on changes in the soft tissue on the medial side of the inferior turbinate, which may have given previous observers the impression that the inferior turbinate had medialised.

Two other recent studies[5,6] have used computer modelling of nasal airflow to demonstrate the aerodynamic effect of inferior turbinate reduction. This approach offers the prospect of using airflow modelling to plan nasal surgery. However, in order to do this, one must know in advance the expected morphological outcome of the surgery. This includes changes in the soft tissue morphology as well as lateralisation of the inferior turbinate bone.

We undertook a study of the validity of such computer modelling for predicting the results of nasal surgery. This involved nasal CT scanning before and after real-life surgery, in order to generate morphological data on which to base our computer models. Thus, we were able to determine the morphological changes that occur in the inferior turbinate following lateral outfracture.

Case report
Ethical approval was obtained to perform CT scans on volunteer patients prior to nasal surgery and again six weeks post-operatively, in order to generate morphological data on which to base computer models of nasal airflow (Queen's University of Belfast Ethics Committee, reference number 290/00).

An Aquillion TSX 101A multislice CT scanner (Toshiba, Tokyo, Japan) was used with a voltage of 120 kV and a current of 100 mA. Images were acquired axially at a slice width of 0.5 mm, a window width of 2500 and a window level of +500.

Prior to CT scanning, patients behaved as though they were attending for rhinomanometry (i.e. quiet breathing in

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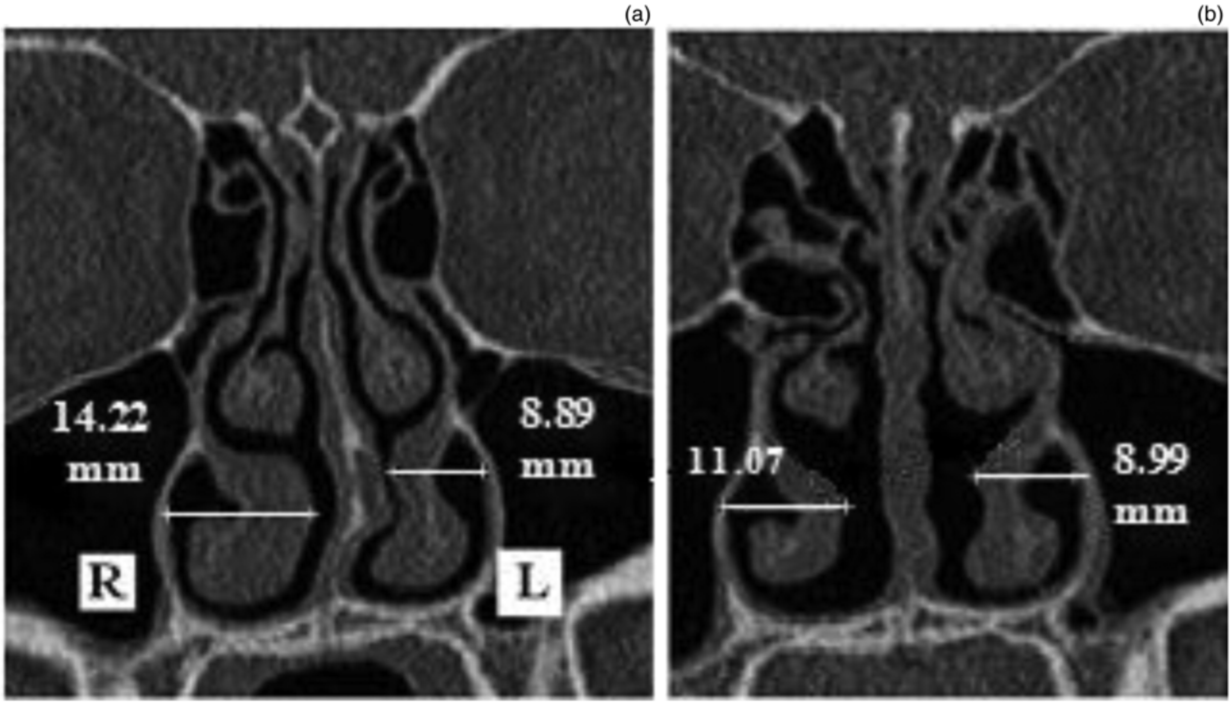

FIG. 1

Coronal computed tomography images of the mid-section of the nasal cavity of patient one (a) before and (b) after septoplasty and lateral outfracture of the inferior turbinates.

a sitting position for 20 minutes prior to scanning, with no smoking and nothing to eat or drink during the previous hour), in an attempt to standardise nasal conditions.

The CT images were reconstructed coronally with a pixel resolution of 0.2 mm. They were displayed using the Mimics software package (Materialise, Lueven, Belgium). We measured the distance from the lateral wall of the nasal cavity to the medial wall of the inferior turbinate at approximately the mid-portion of the inferior turbinate. If the patient's head was at a different angle for the pre- and post-operative scans, the images selected for measurement were chosen to represent the same part of the inferior turbinate. Three-dimensional reconstructions of the nasal cavities, without the nasal septum, were created using Mimics software, in order to better visualise the overall shape of the inferior turbinate (compared with the impression obtained from viewing multiple coronal slices).

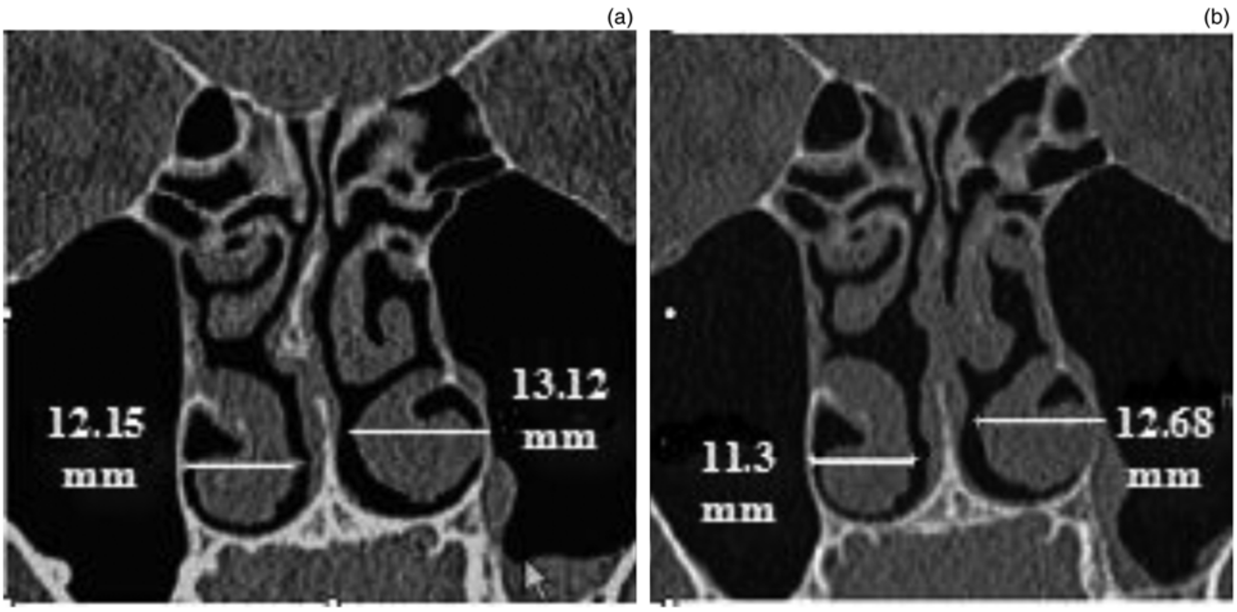

FIG. 2

Coronal computed tomography images of patient two (a) before and (b) after septoplasty, lateral outfracture of the inferior turbinates and left middle turbinoplasty.

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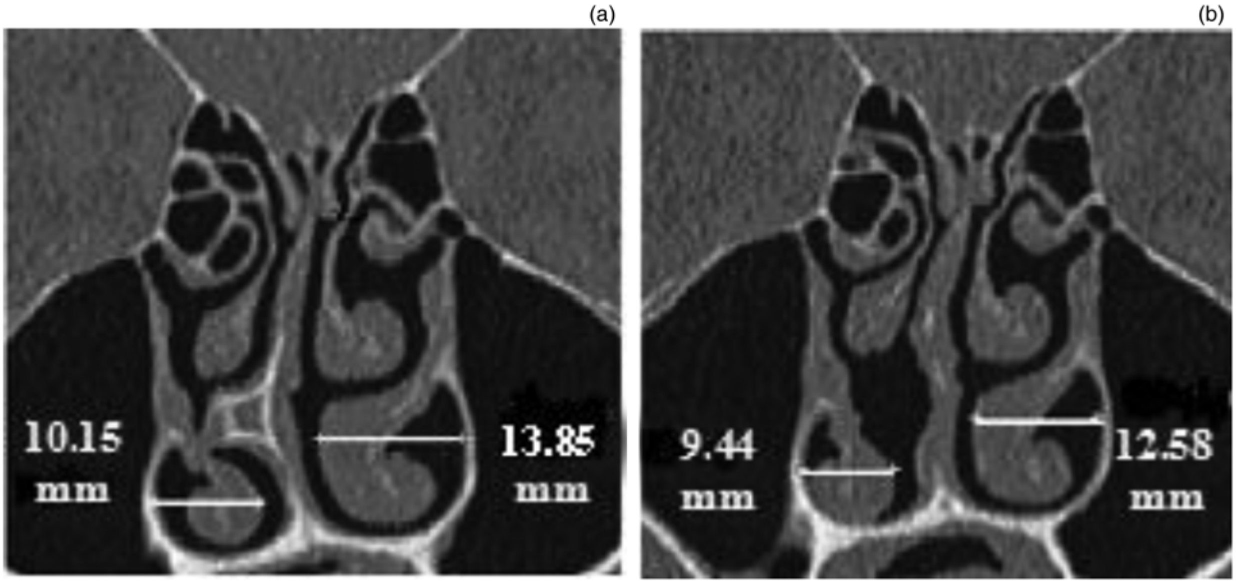

FIG. 3
Coronal computed tomography images of patient three (a) before and (b) after septoplasty and lateral outfracture of the inferior turbinates.

Lateral outfracture of the inferior turbinates was performed for three of the patients recruited to the study. Lateralisation was accomplished by pushing the closed end of a straight pair of Mayo scissors against the medial border of the inferior turbinate. Prior infracturing was not performed.

The first patient was a 26-year-old Caucasian man who complained mostly of right-sided nasal blockage following nasal trauma two years previously. Septoplasty was also performed.

The second patient was a 46-year-old Caucasian man who complained of bilateral nasal blockage. He had sustained nasal injuries playing rugby and had undergone previous septoplasty. Revision septoplasty and reduction of a left concha bullosa were performed in addition to outfracture of the inferior turbinates.

The third patient was a 31-year-old Caucasian woman who complained of bilateral nasal obstruction and rhinorrhoea. Septoplasty was also performed.

Figures 1 to 3 show pre- and post-operative coronal images from the mid-section of the nasal cavity of patients one, two and three, respectively. In Figure 1, there is a dramatic reduction in the volume of the right inferior turbinate, six weeks following outfracture. There is little apparent change in the left inferior turbinate. In Figure 2, the measurements demonstrate that there has been a small amount of lateralisation of the inferior turbinates. In Figure 3, there has been an obvious lateralisation of the right inferior turbinate, but the measurements also demonstrate a lateralisation of the left inferior turbinate. The amount of measured lateralisation is shown in Table I.

TABLE I
INFERIOR TURBINATE LATERALISATION

Pt	Side	Lateralisation (mm)
1	L	−0.1
	R	3.15*
2	L	0.44
	R	0.85
3	L	1.27*
	R	0.71

*Appreciable reduction in turbinate volume contributing to measured lateralisation. Pt = patient; L = left; R = right

Figures 4 to 6 demonstrate pre- and post-operative three-dimensional reconstructions of the nasal cavities with the septum removed, for patients one, two and three, respectively. In Figure 4, the volume reduction of the right inferior turbinate noted in Figure 1 is obvious. There is also some lateralisation of the left inferior turbinate behind the head of the turbinate, along its lower edge, evidenced by the smoother contours and a less well defined dimple in the post-operative state. In Figure 5, no changes to the overall shape of the inferior turbinates can be seen. In Figure 6, the right inferior turbinate has an altered shape, in keeping with the lateralisation seen in Figure 3. On the left, the shape has changed in the area around the head of the inferior turbinate, and the overall size of the turbinate appears to be reduced.

Discussion

These three cases suggest that the effect of lateral outfracture on the size, shape and position of the inferior turbinate is best described as variable. Figure 2 displays the outcome expected based on the current literature: a degree of lateralisation without any significant change in the size or shape of the inferior turbinate. However, Figures 1, 3, 4 and 6 demonstrate that reduction in the volume of the inferior turbinate can occur.

One explanation may be that there was simply a difference in the degree of nasal cavity congestion between the two CT scans, possibly due to the nasal cycle. However, this explanation is unlikely because the state of congestion of other areas of the same nasal cavity is similar during the two scans. Particular reference is made to the septal body (not shown) and the middle turbinate.

Instead, it is proposed that the reduction in volume may result from an effect on the blood supply of the inferior turbinate following outfracture. A recent study of the blood

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supply of the inferior turbinate has shown that, in most turbinates, the arterial supply reaches the soft tissue part of the turbinate by running in the bony lamella, and that it is an end-artery.[7] It is conceivable that a fracture of the bone may in some cases disrupt this blood supply, leading to atrophy of the turbinate.

In addition to changes in the size and position of the inferior turbinate, some minor change can occur in the shape, as seen in the inferior turbinates shown in Figures 4 and 6.

The clinical relevance of these findings is twofold. Firstly, they support prior assertions that the technique of outfracture should only be employed with the aim of obtaining a minor improvement in the nasal airway. Secondly, they offer a possible explanation as to why some patients benefit from this procedure more than others.

The unpredictability of the effects of inferior turbinate outfracture has also been noted by Buyuklu *et al.*[3] They measured the distance from the lateral border of the inferior turbinate bone to the lateral wall of the nose, in Turkish patients with mild to moderate enlargement of the inferior turbinates who were undergoing septoplasty and inferior turbinate outfracture. The same outfracture technique was used. Buyuklu *et al.* demonstrated a decrease in post-operative

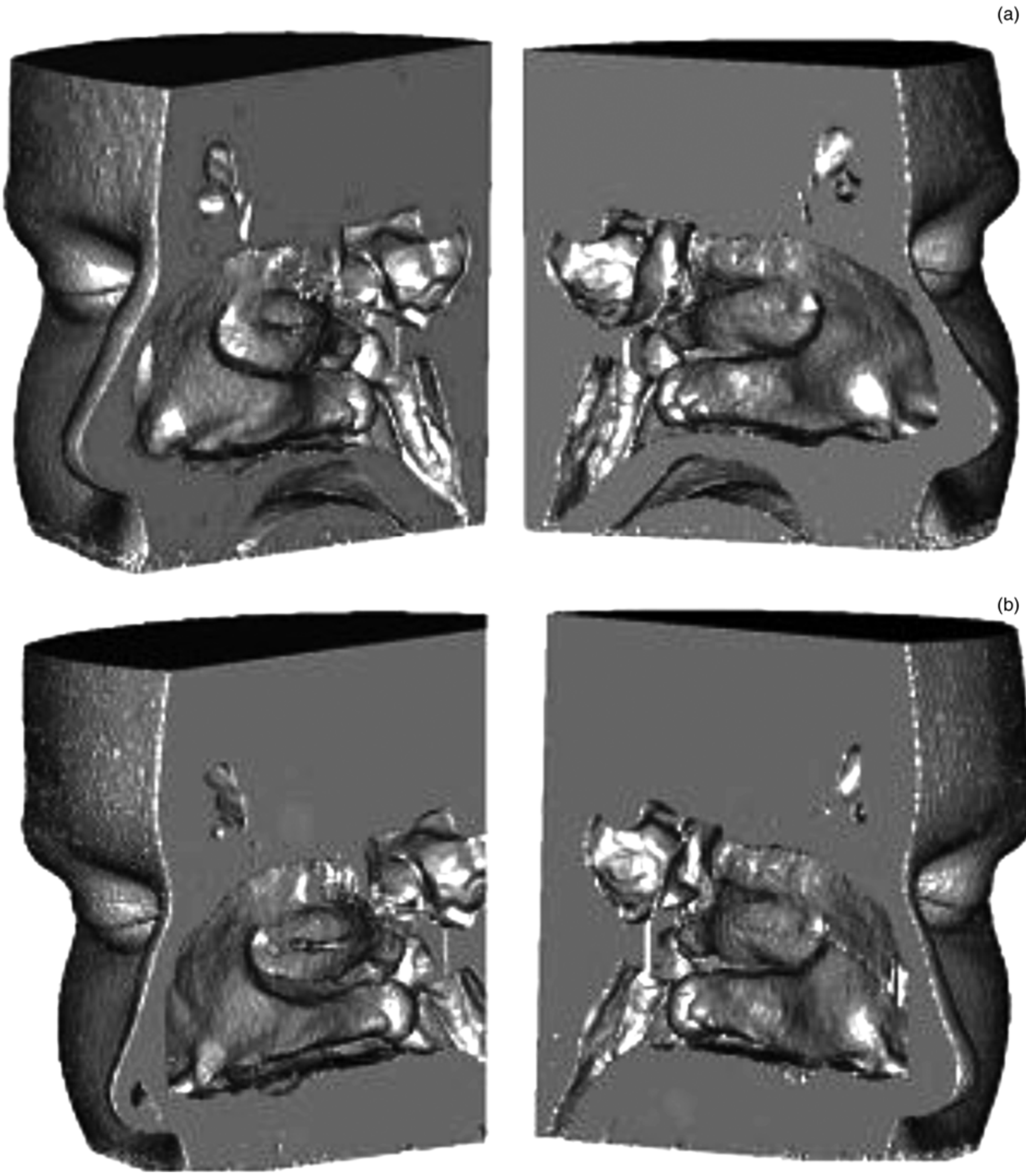

FIG. 4
Three-dimensional reconstruction of the nasal cavities of patient one (a) before and (b) after surgery.

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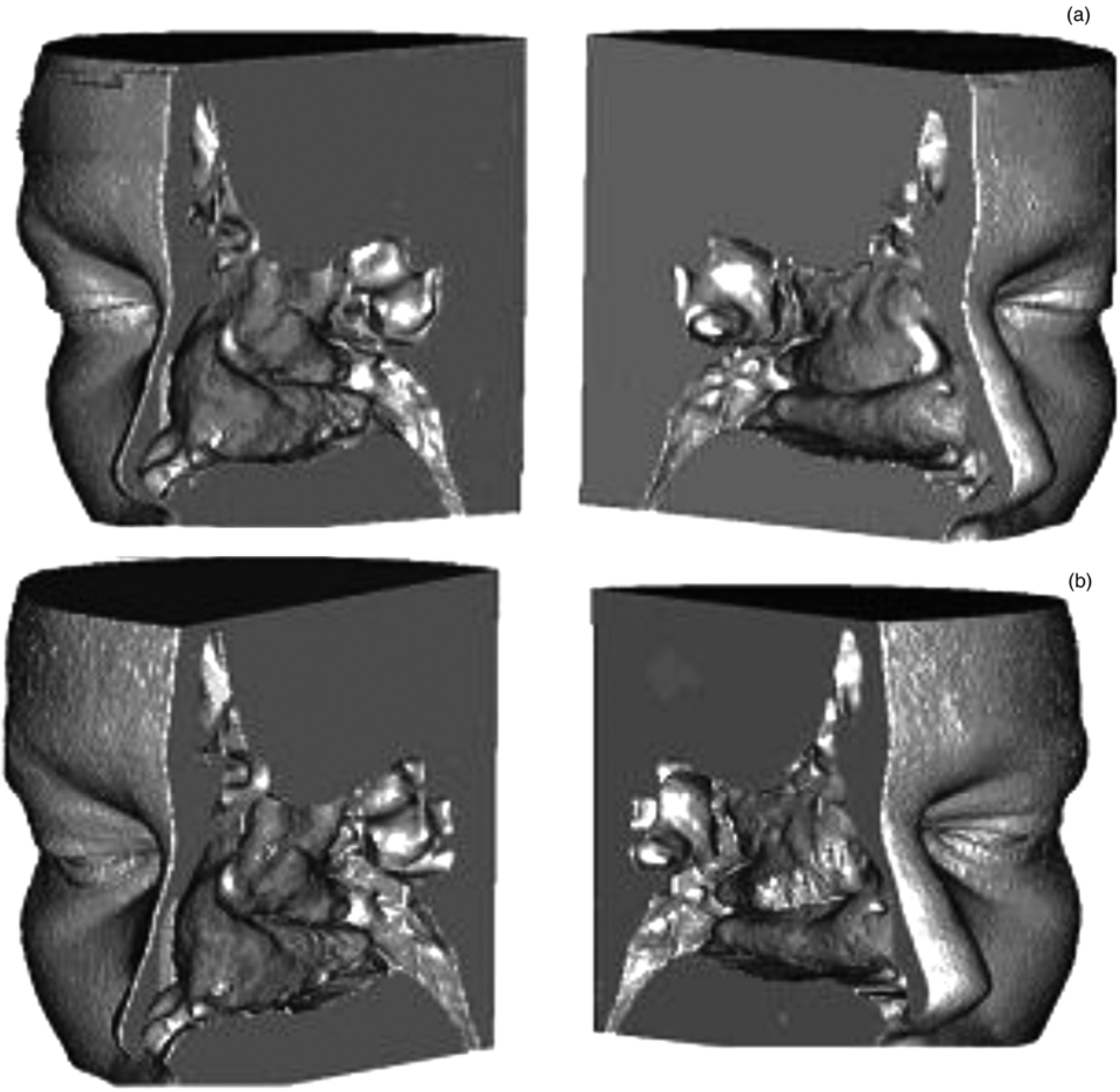

FIG. 5
Three-dimensional reconstruction of the nasal cavities of patient two (a) before and (b) after surgery.

measurements and showed that this was statistically significant. The difference was expressed as a percentage of the pre-operative measurement. The degree of lateralisation averaged 27 per cent at the midpoint of the inferior turbinate, and ranged from 4.6 to 66.3 per cent.

- **There is little research on the expected effect of outfracture on inferior turbinate size, shape and position**
- **Reduction in the distance between the lateral nasal wall and the medial inferior turbinate can vary from 4 to 66 per cent**
- **This study found that lateral outfracture can cause a significant decrease in inferior turbinate volume, although results were inconsistent**
- **A variable amount of shape change and lateralisation can also occur**

Aksoy *et al.*[4] fractured the inferior turbinate medially and then laterally, and performed CT scanning one and six months afterwards, again in a Turkish population. The greatest lateralisation was noted at the level of the origin of the middle turbinate. At one month, there was an average 17 per cent reduction in the distance between the inferior turbinate bone and the lateral nasal wall, which reduced to 14 per cent at six months. The range of measurements was not reported.

The measurements in these two studies were designed to reflect lateralisation of the turbinate bone, and did not take account of any change in the soft tissue volume of the inferior turbinate.

Conclusion

Morphological changes in the inferior turbinate are inconsistent following lateral outfracture, and may include variable degrees of lateralisation, volume reduction and minor shape changes. Volume reduction secondary to impairment

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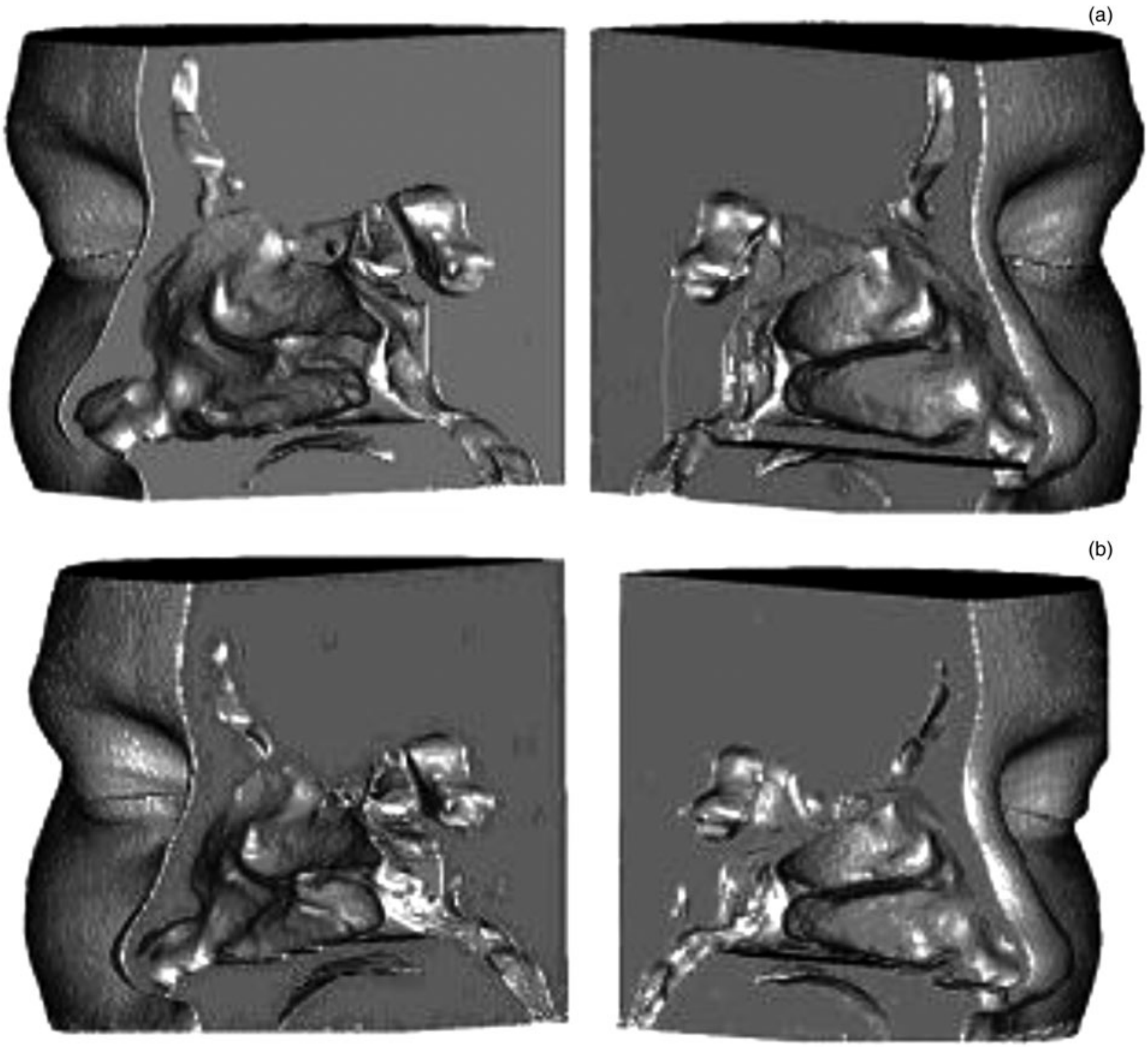

FIG. 6
Three-dimensional reconstruction of the nasal cavities of patient three (a) before and (b) after surgery.

of the end-arterial blood supply as it passes through the fractured bony lamella may explain the superior results observed from this procedure.

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