

Original Article

Efficacy of multi-slice spiral computed tomography-based curved planar reformation combined with nasal endoscopy in the treatment of nasal bone fractures with deformities

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Abstract: Objective: To evaluate the effectiveness of multi-slice spiral computed tomography-based curved planar reformation (MSCT-CPR) combined with nasal endoscopy in treating nasal bone fractures (NBFs) with deformities. Methods: This study included 100 NBF patients with deformities admitted to Second Hospital of Hebei Medical University from June 2022 to June 2024. The control group (n=43) underwent conventional surgery, while the experimental group (n=57) received MSCT-CPR-guided nasal endoscopy. Pre- and post-treatment nasal morphology changes were evaluated. Therapeutic outcomes, nasal appearance, ventilation function, olfactory dysfunction, and nasal cavity parameters (minimum cross-sectional area, nasal cavity volume, and total nasal exhaled volume) were assessed. Postoperative complications (nasal airflow obstruction, intranasal adhesions, cosmetic changes, and postoperative infections) were also documented. Univariate and multivariate analyses (binary logistic regression) were performed to identify potential efficacy determinants. Results: The experimental group achieved a significantly higher total effective rate ($P=0.010$) than the control group, along with superior improvements in nasal appearance, ventilation function, and olfactory performance (all $P<0.05$). Additionally, the experimental group demonstrated more pronounced enhancements in nasal cavity parameters (all $P<0.05$), with a lower overall postoperative complication rate ($P=0.026$). Univariate analysis identified associations between treatment efficacy and variables like patient age, body mass index, fracture type, trauma mechanism, smoking history, and septal involvement (all $P<0.05$); however, these associations did not persist in the multivariate analysis (all $P>0.05$). Conclusion: MSCT-CPR plus nasal endoscopy significantly improves treatment outcomes, enhances nasal function and aesthetic restoration, optimizes nasal cavity morphology, and minimizes postoperative complications in NBFs with deformities.

Keywords: Multi-slice spiral CT, nasal endoscopy, nasal bone fractures, deformity, treatment efficacy

Introduction

Nasal bone fractures (NBFs), the most prevalent type of facial fractures (accounting for approximately 50% of all cases), are dominantly triggered by physical assault, accidental falls, sports-related injuries, and motor vehicle collisions [1, 2]. Such fractures result in structural discontinuities (crack or break) in the nasal framework due to the nose's anatomically vulnerable position and relatively delicate architecture within the facial skeleton [3]. The likelihood of sustaining NBFs in males is nearly twice that of females (risk ratio $\approx 2:1$), irrespec-

tive of age [4]. Clinically, nasal fractures typically present with various degrees of external nasal deformities, frequently coexist with skeletal displacement, soft-tissue swelling involving the nasal and perinasal regions, nasal airway obstruction, and epistaxis [5]. Contemporary management aims to restore both optimal nasal function and aesthetic reconstruction of the naso-orbital complex with minimal invasiveness [6]. Surgical intervention becomes imperative in cases complicated by septal hematoma, those presenting significant anatomical disruption affecting nasal airflow, or when the cosmetic outcomes are unsatisfactory [7].

Conventionally, NBFs with deformities are managed with a two-stage procedure: septoplasty combined with nasal bone reduction. During the acute phase, a closed reduction is performed using nasal bone reduction forceps to restore the nasal structure and prevent malunion. In the second stage, when the fracture is stabilized (3-6 months later), septoplasty corrects secondary deformities, thereby restoring nasal ventilation function and correcting external nasal malformation [8, 9]. However, this approach has limitations, including the prolonged interval between surgeries, the steep learning curve of the operation, and prolonged edema due to extensive mucosal dissection [10]. Multi-slice spiral computed tomography-based curved planar reformation (MSCT-CPR) represents a novel imaging modality for nasal bone assessment. We believe that its integration with nasal endoscopy offers a superior therapeutic option for NBF patients with deformities. This combination allows for precise single-stage management via repositioning under the three-dimensional (3D) navigation of MSCT-CPR and the real-time guidance from nasal endoscopy, particularly beneficial for complex fracture patterns (e.g., comminuted fractures with septal deviation) [11, 12]. MSCT-derived 3D surface images have demonstrated significant clinical value in achieving optimal cranio-maxillofacial surgical outcomes [13].

There is scant research on the application of MSCT-CPR plus nasal endoscopy application for NBFs with deformities. This study aims to assess the combination's clinical advantages in this patient population, with a focus on therapeutic outcomes, nasal appearance, nasal ventilation function, olfactory dysfunction, nasal cavity parameters, and postoperative complications. Meanwhile, efficacy-associated determinants were analyzed. The study may provide novel insights and directions for the future management of NBFs with concomitant deformities.

Clinical data

Study participants

This retrospective analysis selected 100 patients diagnosed with NBFs and deformities, treated at the Second Hospital of Hebei Medical University between June 2022 and June 2024. Participants were allocated into a con-

trol group (Control, n=43) that received standard surgical management and an experimental group (Exp, n=57) treated with MSCT-CPR plus nasal endoscopy. The two cohorts showed similar baseline characteristics ($P>0.05$). The study protocol was reviewed and approved by the Ethical Review Board of the Second Hospital of Hebei Medical University.

Eligibility criteria

Inclusion criteria: (1) Confirmed diagnosis of NBFs with deformities [14]; (2) Presence of nasal obstruction and epistaxis symptoms; (3) No previous treatment for the condition; (4) Age ≥ 18 years; (5) Complete clinical documentation available; (6) Tolerance to surgical treatment.

Exclusion criteria: (1) Asthma or uncontrolled hypertension; (2) Underlying diseases of the nasal bone; (3) History of nasal surgery or trauma; (4) Severe systemic infections or immunodeficiency disorders; (5) Current malignancy; (6) Cognitive or psychiatric impairments.

Treatment methods

The Control group underwent conventional surgical management. The procedure was performed as follows: First, nasal endoscopy was conducted to assess the patient's lesion status. Nasal bone reduction forceps were then used to achieve fracture reduction. Following a 3-6 month fracture healing period, deformity correction surgery was performed. The surgical approach involved an incision at the nasofrontal junction, extending to the nasal floor, with sequential dissection through the mucosa, perichondrium, and cartilage. Under direct endoscopic visualization, the perichondrium on the ipsilateral side of the nasal septum and the mucoperichondrium on the contralateral side were carefully elevated to expose the nasal septal cartilage, its articulation with the vomer, the palatine bone, and the nasal crest of the maxilla. Subsequently, the three linear strips of bone were resected using rongeurs while preserving the connection at the septal cartilage end. Meticulous dissection was performed on both surfaces to fully mobilize the inferior, posterior, and anterior portions of the nasal septum. In cases of severe ethmoid plate deviation, fracture manipulation was considered when indicated, followed by re-centering of the quadrangular cartilage to the midline. Finally,

bilateral perichondrial symmetry was verified to ensure proper anatomical alignment.

The Exp group received a combined treatment approach using MSCT-CPR and nasal endoscopy. The MSCT-CPR procedure was performed as follows: First, the patient was positioned supine with the head secured in the cranial scanning frame, ensuring proper alignment of both the sagittal plane and the orbitomeatal line perpendicular to the examination table. Scanning was then conducted using a Philips 256-slice Brilliance iCT scanner (Wuxi Xirui Medical Equipment Co., Ltd.) with the following parameters: 2.50 mm slice thickness, 2.00 mm pitch, 1.25 mm reconstruction thickness, 120 kV tube voltage, 150-200 mA tube current, and 25 cm field of view. Following data acquisition, the original datasets were transferred to the EBW workstation for processing with CPR technology. Both pre- and post-processed data were subsequently sent to the PACS system, where two hospital radiologists performed diagnoses using a double-blind method. For the nasal endoscopic procedure, the following steps were implemented: Initially, the damaged area at the anterior roof of the nasal cavity was visualized under nasal endoscopy. The MSCT-CPR results were then integrated to accurately determine both the precise location and severity of the fractured collapse. Based on these comprehensive findings, the nasal endoscope was carefully positioned to provide direct visualization of the injured area. Nasal bone reduction forceps were subsequently employed to perform fracture repair and reduction, with the goal of achieving optimal anatomical realignment. Specific techniques were applied according to individual patient conditions: For cases with mild nasal septum deviation, clamping manipulation was performed. When septal cartilage dislocation from the vomerine groove was present, the procedure involved identifying the excess cartilage strip at the inferior edge of the cartilage, followed by parallel excision and meticulous repositioning into the vomerine groove. In patients exhibiting either bilateral or unilateral mucosal damage, the damaged area was sutured and stabilized prior to conducting NBF reduction surgery.

Evaluation metrics

(1) Treatment efficacy [15]: Efficacy was assessed based on the following criteria: Markedly

effective: The nostrils were symmetrical, the nasal bridge was straight, both sides of the nasal dorsum showed significant symmetry, and nasal airflow was unobstructed. Improved: The nostrils exhibited noticeable symmetry, the nasal bridge was mostly normal, both sides of the nasal dorsum were roughly symmetrical, and nasal airflow was slightly obstructed. Ineffective: There was no improvement in nostril symmetry, nasal bridge alignment, nasal dorsum symmetry, or nasal airflow, or symptoms had worsened. The total treatment effective rate was calculated as the proportion of cases classified as markedly effective and improved relative to the total number of cases.

(2) Nasal appearance, ventilation function, and olfactory dysfunction: Visual Analogue Scale (VAS) scores were used to assess nasal appearance, ventilation function, and olfactory dysfunction pre- and postoperatively [16]. Nasal airflow function: 0-3: excellent nasal airflow; 4-6: good nasal ventilation function; 7-8: poor nasal ventilation function; 9-10: complete nasal airflow obstruction. Nasal appearance: 0: no deformity; 10: severe deformity with significant cosmetic impact. Olfactory dysfunction: 0: no olfactory impairment; 10: severe impairment affecting daily life, with complete loss of olfactory function.

(3) Nasal cavity parameters [17]: Before and after surgery, patients rested in a seated position for 15 minutes to stabilize their condition. An A1 acoustic rhinometer equipped with an appropriate probe (Shanghai Huanxi Medical Equipment Co., Ltd.) was used to seal the nasal cavity. After patients held their breath for 3-5 seconds, the following parameters were recorded: minimum cross-sectional area (MCSA), nasal cavity volume, and total nasal exhaled volume.

(4) Postoperative complications [18]: The incidence of adverse reactions, including restricted airflow, nasal adhesions, cosmetic changes, and postoperative infections, was observed and recorded for both groups.

Statistical methods

Statistical analyses were conducted utilizing SPSS version 22.0 (IBM Corp., Armonk, NY, USA). Continuous variables following a normal distribution were expressed as mean $\pm$ stan-

Table 1. Comparison of baseline characteristics between the two groups

Factor	n	Control (n=43)	Exp (n=57)	t/ χ^2	P
Gender				0.477	0.490
Male	62	25 (58.14)	37 (64.91)		
Female	38	18 (41.86)	20 (35.09)		
Age (years)	100	44.86 $\pm$ 10.37	42.86 $\pm$ 11.69	0.889	0.376
Body mass index (kg/m ²)	100	23.14 $\pm$ 2.41	23.30 $\pm$ 2.31	0.337	0.737
Fracture type				0.070	0.792
Open fracture	45	20 (46.51)	25 (43.86)		
Closed fracture	55	23 (53.49)	32 (56.14)		
Trauma mechanism				0.198	0.657
High-energy trauma	35	14 (32.56)	21 (36.84)		
Low-energy trauma	65	29 (67.44)	36 (63.16)		
Smoking history				1.360	0.244
No	69	27 (62.79)	42 (73.68)		
Yes	31	16 (37.21)	15 (26.32)		
Alcohol abuse history				0.069	0.792
No	78	33 (76.74)	45 (78.95)		
Yes	22	10 (23.26)	12 (21.05)		
Nasal septum involvement				0.010	0.752
No	46	19 (44.19)	27 (47.37)		
Yes	54	24 (55.81)	30 (52.63)		

dard deviation ($\bar{x}\pm sd$) and compared using Student's t-test. Categorical data were reported as frequency counts with percentages [n (%)] and evaluated using Pearson's chi-square (χ^2) tests. Multivariate binary logistic regression analysis was performed to identify independent predictors of treatment outcomes in patients with NBFs accompanied by deformities. Statistical significance was defined as a two-tailed *P*-value less than 0.05.

Results

Baseline characteristics

The two groups demonstrated comparable baseline characteristics, including gender distribution, age, body mass index (BMI), fracture type, trauma mechanism, smoking history, alcohol abuse history, and nasal septum involvement (all *P*>0.05). Detailed demographic and clinical data are presented in **Table 1**.

Treatment efficacy

Pre- and post-treatment MSCT-CPR images of the Exp group are shown in **Figure 1**. The Exp group exhibited a significantly higher total effective rate than the Control group (*P*<0.05).

Comparative outcomes are summarized in **Table 2**.

Assessment of nasal outcomes: nasal appearance, nasal ventilation function, and olfactory dysfunction

VAS scores were used to evaluate nasal appearance, ventilation function, and olfactory dysfunction before and after treatment. While no significant intergroup differences were observed at baseline (all *P*>0.05), both groups showed marked post-treatment improvements (all *P*<0.05). Notably, the Exp group achieved significantly better outcomes than the Control group across all measured parameters, including nasal appearance, ventilation function, and olfactory dysfunction (all *P*<0.05). These results are illustrated in **Figure 2**.

Nasal-related parameters

Nasal MCSA, nasal cavity volume, and total nasal exhaled volume were assessed in both groups before and after treatment. At baseline, no statistically significant differences were observed between the two groups for any parameter (*P*>0.05). Following treatment, all

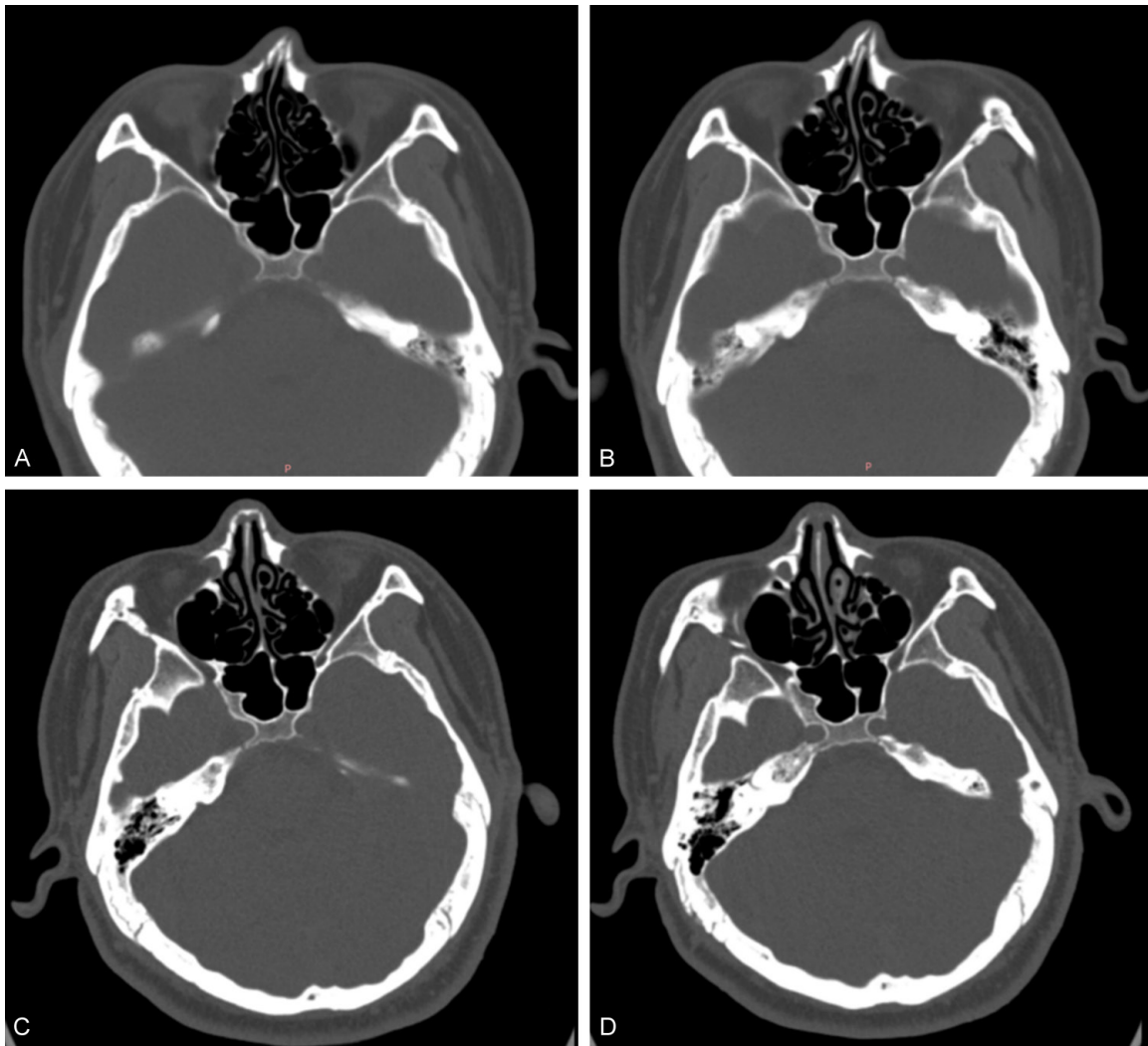


Figure 1. Comparative MSCT-CPR images demonstrating pre- and post-treatment outcomes. A, B. Pre-treatment images demonstrating a right nasal bone fracture with slight displacement of the fractured segments. C, D. Post-treatment images showing proper alignment of the fractured nasal bone segments. Note: MSCT-CPR, multi-slice spiral computed tomography-based curved planar reformation.

Table 2. Comparison of treatment efficacy between the two groups

Factor	Control (n=43)	Exp (n=57)	χ^2	P
Markedly effective	20 (46.51)	29 (50.88)		
Improved	12 (27.91)	24 (42.11)		
Ineffective	11 (25.58)	4 (7.02)		
Total effectiveness	32 (74.42)	53 (92.98)	6.625	0.010

three metrics increased significantly in both groups ($P < 0.05$). However, the Exp group exhibited notably greater improvements compared to the Control group, with significantly higher values in nasal MCSA, nasal cavity volume, and total nasal exhaled volume ($P < 0.05$). These results are illustrated in **Figure 3**.

Postoperative complications

Postoperative complications, including nasal airflow obstruction, nasal adhesions, cosmetic changes, and postoperative infections, were evaluated. The incidence of postoperative complications was significantly lower in the Exp

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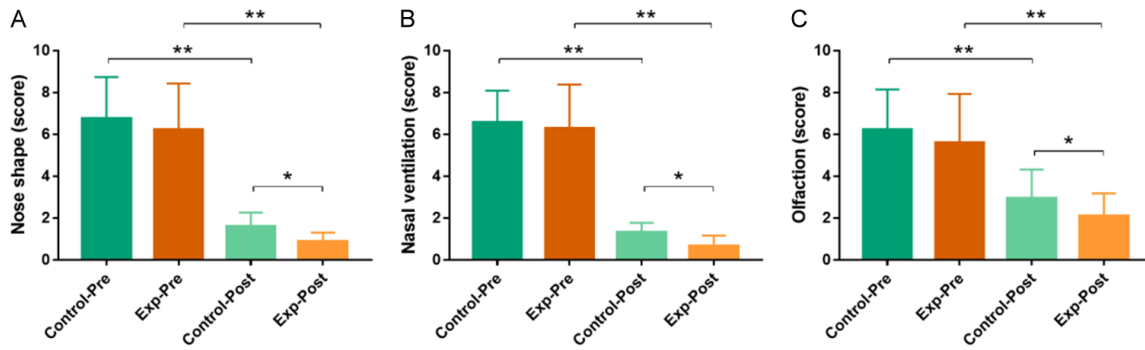


Figure 2. Comparison of VAS scores for nasal outcomes between the two groups before and after treatment. A. Nasal appearance scores pre- and post-treatment. B. Nasal ventilation function scores pre- and post-treatment. C. Olfactory dysfunction scores pre- and post-treatment. Notes: * $P<0.05$; ** $P<0.01$. VAS, Visual Analogue Scale.

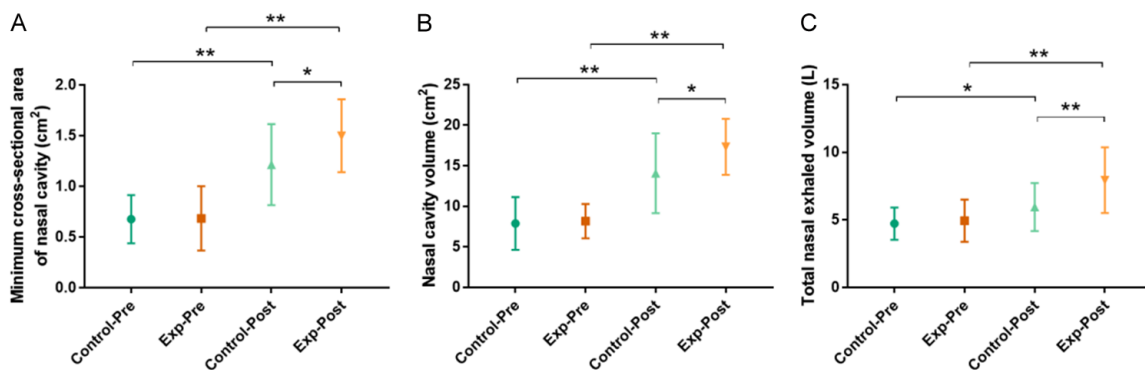


Figure 3. Comparison of nasal-related parameters before and after treatment between the two groups. A. Nasal minimum cross-sectional area. B. Nasal cavity volume. C. Total nasal exhaled volume. Notes: * $P<0.05$, ** $P<0.01$.

Table 3. Comparison of incidence of postoperative complications between the two groups

Adverse events	Control (n=43)	Exp (n=57)	χ^2	P
Nasal airflow obstruction	7 (16.28)	4 (7.02)		
Nasal adhesions	3 (6.98)	2 (3.51)		
Cosmetic changes	4 (9.30)	2 (3.51)		
Postoperative infections	2 (4.65)	2 (3.51)		
Total	16 (37.21)	10 (17.54)	4.927	0.026

group (17.54%) than that in controls (37.21%) ($P<0.05$). Detailed data are presented in **Table 3**.

Predictors of treatment efficacy in NBF patients with deformities

Univariate analysis indicated that age, BMI, fracture type, trauma type, smoking history, and nasal septum involvement significantly affected treatment efficacy ($P<0.05$). However, after performing binary logistic regression, none of these factors emerged as independent

predictive factors ($P>0.05$). See **Tables 4-6** for details.

Discussion

In deformity-complicated NBF patients, delayed or inadequate treatment can adversely affect both facial aesthetics and nasal function, potentially leading to restricted nasal airflow, respiratory distress, and associated life-threatening risks [19]. Furthermore, the inherent complexity of NBFs - characterized by severity and skeletal instability - presents considerable

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Table 4. Univariate analysis of factors influencing treatment efficacy in nasal bone fracture patients with deformities

Factor	n	Ineffective group (n=15)	Effective group (n=85)	χ^2	P
Gender				0.563	0.453
Male	62	8 (53.33)	54 (63.53)		
Female	38	7 (46.67)	31 (36.47)		
Age (years)				4.913	0.047
<45	53	4 (26.67)	49 (57.65)		
≥45	47	11 (73.33)	36 (42.35)		
Body mass index (kg/m ²)				-	0.012
<24	51	3 (20.00)	48 (56.47)		
≥24	49	12 (80.00)	37 (43.53)		
Fracture type				-	0.004
Open fracture	45	12 (80.00)	33 (38.82)		
Closed fracture	55	3 (20.00)	52 (61.18)		
Trauma mechanism				7.779	0.005
High-energy trauma	35	10 (66.67)	25 (29.41)		
Low-energy trauma	65	5 (33.33)	60 (70.59)		
Smoking history				6.938	0.008
No	69	6 (40.00)	63 (74.12)		
Yes	31	9 (60.00)	22 (25.88)		
Alcohol abuse history				3.332	0.067
No	78	9 (60.00)	69 (81.18)		
Yes	22	6 (40.00)	16 (18.82)		
Nasal septum involvement				-	0.047
No	46	3 (20.00)	43 (50.59)		
Yes	54	12 (80.00)	42 (49.41)		

Table 5. Variable assignment for influencing factors

Factor	Variable	Assignment
Age (years)	X1	<45=0, ≥45=1
Body mass index (kg/m ²)	X2	<24=0, ≥24=1
Fracture type	X3	Closed fracture =0, open fracture =1
Trauma mechanism	X4	Low-energy trauma =0, high-energy trauma =1
Smoking history	X5	No =0, yes =1
Nasal septum involvement	X6	No =0, yes =1

challenges in surgical reduction and facial reconstruction [20]. This study evaluates various surgical interventions, aiming to provide solid evidence for optimizing surgical approaches in this patient population.

The present study demonstrated superior overall treatment efficacy when combining MSCT-CPR with nasal endoscopy compared to conventional surgical approaches. This enhanced efficacy can be attributed to several factors: (1) Precision in surgical planning - MSCT-CPR en-

ables 3D visualization of fracture lines, displacement severity, and adjacent structural damage (e.g., nasal septum involvement), thereby facilitating accurate preoperative assessment and minimizing intraoperative blind maneuvers. (2) Enhanced intraoperative visualization - Nasal endoscopy provides high-definition, multi-angled visualization, particularly beneficial for the reduction of deep or obscured fractures. This reduces the likelihood of incomplete reduction or overcorrection, which are common limitations of traditional

Table 6. Multivariate regression analysis of treatment efficacy predictors

Factor	β	SE	Wald	P	OR	95% CI
Age (years)	-0.528	0.445	1.407	0.236	0.590	0.246-1.411
Body mass index (kg/m ²)	-0.326	0.436	0.560	0.454	0.722	0.307-1.696
Fracture type	-0.401	0.440	0.831	0.362	0.670	0.283-1.586
Trauma mechanism	0.072	0.484	0.022	0.882	1.074	0.416-2.774
Smoking history	0.277	0.523	0.280	0.597	1.319	0.473-3.680
Nasal septum involvement	-0.820	0.434	3.570	0.059	0.440	0.188-1.031

Note: β , beta coefficient; SE, standard error; OR, odds ratio; 95% CI, 95% confidence interval.

surgical techniques. (3) Minimized tissue trauma - The endoscopic approach minimizes mechanical trauma to the nasal mucosa, thereby mitigating postoperative edema, scar formation, and accelerating functional recovery [21-23]. As noted in Wang et al.'s research [24], pairing MSCT and 3D imaging with a patient's trauma history helps differentiate fractures from intact structures - a finding consistent with and complementary to this study.

Besides, MSCT-CPR plus nasal endoscopy demonstrates superior therapeutic effectiveness over conventional surgical procedures in treating deformity-complicated NBF patients, particularly in improving nasal appearance, ventilation function, and olfactory dysfunction. This enhanced effectiveness stems from the technology's ability to achieve personalized reduction of fracture fragments, especially in cases complicated by nasal septum deviation, where synchronous correction can restore nasal symmetry and improve both ventilation and appearance [25, 26]. Furthermore, the minimally invasive characteristics of endoscopic procedures contribute to the nasal ciliary function preservation and enhancement, while its precision in anatomical reconstruction effectively addresses ventilation impairments [27]. As noted by Kim et al. [28], cosmetic open rhinoplasty applied to acute NBFs with existing deformities leads to markedly higher satisfaction levels and optimized nasal-facial aesthetics.

Compared to traditional surgical methods, MSCT-CPR plus nasal endoscopy also shows markedly better outcomes in normalizing MCSA, nasal cavity volume, and total nasal exhaled volume. This confirms the technique's superior ability to restore physiological nasal ventilation. Existing literature supports this finding, suggesting that the combined approach offers more comprehensive structural recon-

struction in nasal fracture-deformity cases. Its diagnostic precision enables the identification and repair of even minor fractures, while postoperative imaging verification ensures accurate reduction and confirms the recovery of nasal cavity volume and airflow parameters to physiological levels [28].

Regarding clinical safety, MSCT-CPR combined with nasal endoscopy for NBFs and concurrent deformities significantly reduces postoperative complications, such as airway limitation, nasal adhesions, cosmetic changes, and postoperative infections. This can be attributed to the minimal invasiveness of the approach, which avoids the extensive tissue dissection required in open surgery, thereby minimizing tissue trauma and lowering nasal adhesion risk. Furthermore, by reducing the duration of nasal packing, this technique decreases the likelihood of nasal airflow obstruction and mucosal atrophy [29]. Extensive research efforts have been dedicated to refining the diagnosis and treatment of NBFs. Among these, Rashid et al. [30] reported that cone-beam CT facilitates the assessment of septal fracture alignment and displacement in the absence of endoscopy. This advancement provides valuable clinical guidance for instrument-assisted reduction. Additionally, a study [31] conducted by Yang L's team demonstrated that employing optimized CT scanning protocols with Insight Tool-kit (ITK)-driven 3D annotation significantly enhances the diagnostic value of NBFs, providing superior delineation of fractured nasal bones and nearby tissues.

In the univariate screening, age, BMI, fracture type, trauma mechanism, smoking history, and septal involvement were initially identified as potential treatment outcome predictors. Nevertheless, none of them maintained statistical significance in further multivariate modeling.

Certain limitations in this study need to be addressed through further work. First, indicators such as inflammation and oxidative stress were not analyzed, and including these markers could deepen our understanding of the clinical effects of the two treatment regimens. Second, a deeper exploration of the factors affecting patients' treatment outcomes is needed to develop targeted, optimized management measures. Lastly, extended follow-up observations should be implemented to allow for a more thorough comparison of the long-term prognostic influences of both therapies.

Conclusion

The combined application of MSCT-CPR and nasal endoscopy for NBFs with concomitant deformities significantly enhances clinical efficacy. It improves nasal morphology, ventilation function, and olfactory performance, optimizes nasal cavity parameters, and ensures a favorable safety profile.

Disclosure of conflict of interest

None.

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