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Management of Acute Nasal Bone Fractures in Adults: Systematic Review and Meta-Analysis

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Abstract

Background: The optimal timing, patient selection, and surgical technique for the management of nasal trauma are not yet clearly established. The choice of surgical technique also varies depending on the severity of the injury, the patient's individual anatomy, surgeon selection and expertise.

Objective: To review previous studies discussing the treatment of acute nasal fractures in adults.

Methods: A systematic review and meta-analysis was conducted in March 2022 for papers published between 2002 and 2022. To compare the outcomes of closed nasal bone reduction, septal reduction to other treatments as open reduction, limited septoplasty, septorhinoplasty, and delayed rhinoplasty for nasal bone fractures. Also, to assess how reduction type, type of anesthesia, presence of septal fractures and the time interval between injury and treatment could affect patient satisfaction post operatively, rate of complications, revisional surgeries and olfactory dysfunction.

Results: A meta-analysis of 19 studies found that reduction type and timing interval between injury and treatment had a significant impact on patient satisfaction. Reduction type and the type anesthesia also had a significant impact on post-operative complication rates.

Conclusion: Open nasal reduction (ONR) is associated with higher patient satisfaction, however, closed nasal reduction may be safer. Patients with septal fractures are less satisfied with their results. General anesthesia has higher satisfaction rates and lower complication rates than local anesthesia. Early surgical intervention within 2 weeks of trauma is recommended.

Key Words: *Nasal bone reduction – Reduction types – Satisfaction – Septal fracture.*

Ethical Committee: Approved by the ethical committee of Ain Shams Faculty of Medicine; FMASU MS 141/2023.

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Introduction

Nasal bone fracture (NBF) is the most common fracture of the facial skeleton. Most of the NBFs in adults are due to fights (36.3%), traffic accidents (20.8%), sports (15.3%), and falls (13.4%) [1]. The type and severity of nasal bone fracture vary depending on the mechanism of injury, direction (or vector) of the impact and the force of injury. Moreover, nasal bone fractures are frequently accompanied by septal fractures and soft tissue injuries, such as lacerations and skin defects that require distinctive management. Inaccurate initial diagnosis increases the risk for the development of complications and patient dissatisfaction [1].

Han et al., classified Nasal fractures according to the CT scans into type I, unilateral thin bone fractures with displacement; type II, bilateral thin bone fractures with displacement; and type III, bilateral thin and thick bone fractures. Type IV fractures were accompanied by fractures of the neighboring bones, including the orbital wall, ethmoid bone, frontal bone, lacrimal bone, or maxilla [2]. This classification was modified by Kim et al., adding Types IIo & IIs, and IIIo & IIIs with "o" and "s," according to the absence (o) or presence (s) of septal fracture [3], Fig. (1).

Different modalities for management of nasal bone fractures were described. Closed nasal fracture & septal reduction done under local or general anesthesia, depending on the surgeon's and patient's preference as well as characteristics, open reduction with limited septoplasty through hemi-transfixion incision on the side of dislocation, early full septo-rhinoplasty approach in the initial treatment or delayed Rhinoplasty [4]. Choi et al., found that 22.95% of patients who underwent closed reduction had postoperative aesthetic complications, including deviated nose (19.97%), nasal hump (1.64%), and saddle nose deformity (1.64%) [5]. Others advocated concomitant rhinoplasty with fracture reduction for acute nasal bone fracture. Through the rhinoplasty approach, the nasal bone can be reduced more accurately satisfying the aesthetic demands of the patients at the same time [6,7]. On the contrary, Wang et al., debated the primary use of open rhi-

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noplasty in an acute setting stating that there are no clearly accepted indications for timing, patient selection, and surgical technique [8]. In our study, we compared the outcome for other previous studies that discussed the treatment of acute nasal bone fractures using closed nasal bone and septal reduction in comparison to other modalities by meta-analytical study through several data bases.

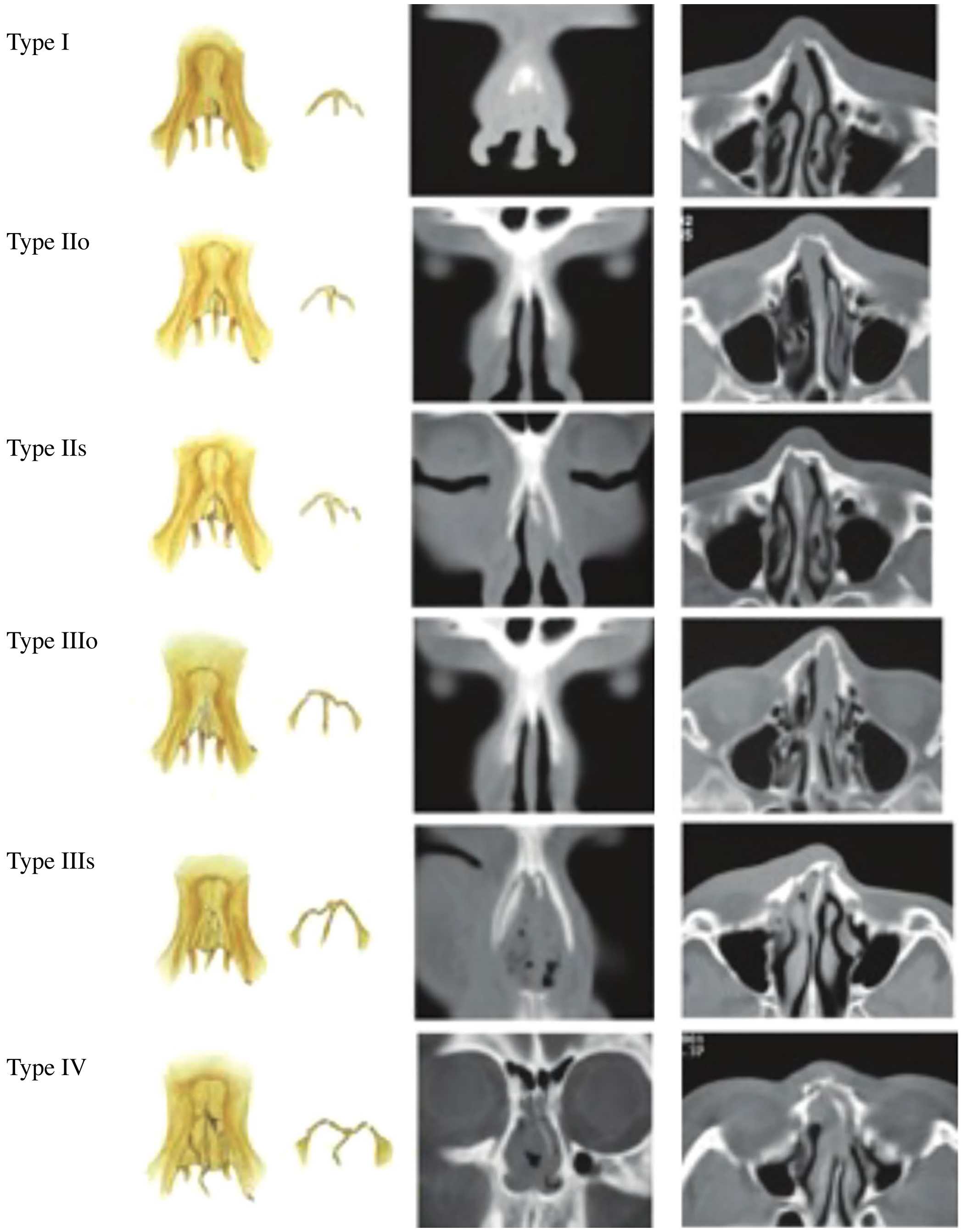

Fig. (1): Shows classification of nasal fractures [3].

Patients and Methods

Search strategy:

A comprehensive search of several databases and additional sources was conducted to identify potentially relevant studies in the period between 2002 and 2022. The primary databases search included the Egyptian Knowledge Bank (EKB), PubMed, EMBASE, Web of Science, Scopus, and the Cochrane Library. A PubMed search strategy included a combination of controlled vocabulary terms (MeSH) as well as free-text terms for key concepts related to nasal bone fractures, surgical repair techniques, and postoperative complications. The search involved different combinations of keywords such as nasal bone fracture, acute nasal trauma, closed reduction, open reduction, septal fracture, soft tissue injury, rhinoplasty, postoperative complications, revision rhinoplasty, aesthetic outcomes, surgical technique, and patient satisfaction. The search had no geographic or ethnic restrictions. To supplement the database searches, we manually reviewed lists of included studies and relevant review articles identified through the search.

Study selection:

Search results were imported into Mendeley citation management software for de-duplication. The screened titles and abstracts of the identified studies were classified according to predefined eligibility criteria listed below:

The Inclusion criteria were randomized controlled trials, quasi-randomized trials, and high-quality cohort studies comparing outcomes between different reduction techniques for acute nasal bone fractures in adults aged 18-65 years. Eligible comparators included no surgery, closed reduction, open reduction, limited septoplasty, septorhinoplasty, and delayed rhinoplasty. Studies were required to report at least one of the following postoperative complications as an outcome measure: Nasal airway obstruction, nasal deviation, nasal valve collapse, subperichondral fibrosis, synechiae, patient dissatisfaction, or revision surgery rate. While the Exclusion criteria were case series with fewer than 10 patients, case reports, reviews, editorials, letters, conference abstracts, and non-English studies. After title/abstract screening, full texts were assessed for inclusion or exclusion criteria. The systematic review was performed according to the updated PRISMA guidelines 2020 (preferred reporting items for systematic reviews) **[9]**.

Quality assessment:

The Cochrane risk of bias assessment tool was employed to assess the potential risk of bias in the included studies.

Comparisons performed:

We assessed patients' outcomes after nasal bone fracture reduction (satisfaction, revision rate, complication rates, and nasal deformities) according to four variables; type of reduction, type of anesthesia, presence of septal fracture, and average time to procedure. The Satisfaction rate was further classified among studies into good satisfaction, excellent satisfaction and not satisfied. Complications were further divided into olfactory complication and the composite complication rates (all other complications including olfactory). This was due to the fact that olfactory complications had been mentioned separately and have had more statistical impact.

Data synthesis and analysis:

All outcomes and data were analyzed using the inverse variance method. The results were presented as odds ratios (ORs) with 95% confidence intervals (CIs) for each outcome. The heterogeneity between studies was assessed using the measure of heterogeneity (I^2) statistic, and a value of greater than 50% was considered substantial heterogeneity. The statistical analysis was performed using the Review Manager software (RevMan version 5.4).

Results

The results for the search were categorized into five outcomes; first patient satisfaction that was further divided into good and excellent satisfaction, revision rate, complication rates, olfactory dysfunction, and nasal deformities. All these outcomes are plotted against four variables: Type of reduction, type of anesthesia, presence of septal fractures, and the average time between injury and operation. Summary of the included studies is shown in Fig. (8). Summary of the involved studies; authors, year of publication, journal, main procedure done, duration of study, study design and the level of evidence is shown in Table (1).

A- *Satisfaction:*

1- *Good satisfaction:*

a- Reduction type: The overall pooled estimate of patients reporting good satisfaction across all included studies was 65.89% (95% CI 56.23% to 74.39%). The heterogeneity among all studies was also high (I^2=86%, p<0.01), necessitating the use of a random effects model. There was a marginally significant difference between groups under the random effects model (p=0.05).

b- Type of anesthesia. Test for subgroup differences was insignificant under the random effects model (p=0.45), suggesting that the type of anesthesia (both, general and local) did not significantly influence good patient satisfaction rates across these studies.

c- Septal fractures: The test for subgroup differences indicated no significant differences under the random effects model (p=0.82), suggesting that the presence or absence of a septal fracture did not significantly influence patient satisfaction rates across these studies.

d- The average time to procedure. The test for subgroup differences showed no significant differences under the random effects model (p=0.16), indicating that the time from injury to surgery did not significantly influence patient satisfaction rates across these studies.

Table (1): Summary of the involved studies, year of publication, and types of studies. LOE is the level of evidence.

No.	Authors	Year	Journal	Main Procedure	Duration	Study design	LOE
1	Arnold et al.	2019	Laryngoscope	Closed nasal reduction without septal reduction	January 2015 and December 2016	Retrospective review	IV
2	Choi et al.	2020	Archives of Craniofacial Surgery	Closed reduction	January 2017 - December 2018	Retrospective cohort study	IV
3	Elzayat et al.	2016	Int. J. Oral Maxillofac. Surg	Group I managed by reduction using Ash forceps and a Boies elevator. Group II managed by septo-plasty.	July 2013 to june 2015	Randomized control trial	II
4	Fattahi et al.	2006	Journal of oral and maxillofa-cial surgery	Closed technique using Asch, Walsham, and Boies forceps and elevators	January 2001 and October 2004	Retrospective study	IV
5	Han et al.	2011	Journal of Oral and Maxillofa-cial Surgery	Closed reduction	January 2006 - December 2008	Retrospective cohort study	IV
6	Khwaja et al.	2007	Rhinology	Digital pressure, instrumentation for depressed nasal bones	27 months (Nov 99 – Jan 2003)	Randomized control trial	II
7	Kim et al.	2018	Clinical and Experimental Otorhinolaryngology	Concomitant rhinoplasty and fracture reduction	January 2010 and June 2016.	Retrospective review of medi-cal records	IV
8	Kim et al.	2017	Archives of Craniofacial Surgery	Closed reduction	March 2013 - May 2014	Single-institution prospective cohort study	IV
9	Kim et al.	2012	Acta Otolaryngologica	Open reduction through an intercartilagin-ous inci-sion	August 2001 – February 2008	Retrospective review of medi-cal records	IV
10	Lim et al.	2017	The Journal of Craniofacial Surgery	Closed reduction using C-arm fluoroscopy	January 2010, to December 2011	Retrospective analysis	IV
11	Neaman et al.	2013	Aesthetic Surgery Journal	Open rhinoplasty (72.7%), closed rhinoplasty (27.3%)	From 1998-2008	Retrospective chart review	IV
12	Reilly et al.	2007	Archives of Facial Plastic Surgery	1) Closed approach to the nasal pyramid, 2) Closed approach to the nasal pyramid with septoplasty, 3) Open approach to the nasal pyramid, 4) Open approach to the nasal pyramid with septoplasty, 5) Prior cosmetic septorhinoplas-ty	5-year period (January 1, 2001, to December 31, 2005)	Retrospective medical record review	IV
13	Rhee et al.	2004	Plastic and Reconstructive Surgery	Closed reduction of nasal bone fracture only, sep-toplasty or submucosal resection for severe septal fractures of perioperative septal grade 3 or higher	From 1997 to 2001	Prospective review	IV
14	Sharma et al.	2014	Surgery Research and Practice	Closed reduction	April 2011 to March 2012.	Prospective study	IV
15	Savas et al.	2023	Ulus Travma Acil Cerrahi Derg	Closed or open reduction	December 2018 to September 2020	Retrospective review	IV
16	Staffel et al.	2002	Laryngoscope	1) Closed reduction, 2) Open reduction with septo-plasty, completion osteotomies, and release of the upper lateral cartilages if needed	Not specified	Retrospective study	IV
17	Vilela et al.	2014	International Archives of Otorhinolaryngology	Closed reduction of nasal fractures under local anesthesia	May 2010 - September 2011	Longitudinal cohort study	III
18	Wild et al.	2003	The Surgeon	Manipulation under local anesthesia (LA) or general anesthesia (GA)	July to September 2001	Prospective study	IV
19	Yoon et al.	2022	The Journal of craniofacial surgery	Closed reduction	1 year and 4 months (Sep 2017 - Dec 2018)	Retrospective	IV

2- *Excellent satisfaction:*

a- Reduction type: The test for subgroup differences indicated significantly higher rates of good satisfaction with the open nasal reduction subgroup using the random effects model (*p*<0.01) (Fig. 2).

b- Type of anesthesia: The test for subgroup differences indicated significant differences using the random effects model (*p*<0.01). This suggests that the type of general anesthesia is associated with higher rates of excellent patient satisfaction rates across these studies (Fig. 3).

c- Presence of septal fractures: The test for subgroup differences indicated significant differences using the random effects model (*p*=0.04). This suggests that the presence of a septal fracture significantly reduced patient satisfaction rates across these studies (Fig. 4).

d- The average time to procedure: The test for subgroup differences showed significant differences using the random effects model (*p*<0.01). This indicates that the time of surgical intervention significantly influenced patient satisfaction rates across these studies.

B- *Revision:*

1- Reduction type: Tests for subgroup differences do not indicate significant differences under the common effects model (*p*=0.68). This suggests that the differences in revision rates across the closed nasal reduction, open nasal reduction, and Mixed subgroups are not statistically significant.

2- Type of anesthesia: Tests for subgroup differences do not indicate significant differences under the common effects model (*p*=0.65). This suggests that the differences in revision rates across different anesthetic types are not statistically significant.

3- Presence of septal fracture: Insignificant differences were detected (*p*=0.54). This suggests that the differences in revision rates between the Septal Fracture and No Septal Fracture are not statistically significant.

4- Average time to procedure: Insignificant differences were found (*p*=0.71). Suggesting the differences in revision rates between the different subgroups are not statistically significant.

C- *Complications:*

1- Reduction type: The tests for subgroup differences indicate significant differences under the random effects model (*p*<0.01). This suggests that the composite complication rates are significantly lower in closed nasal reduction compared to both open nasal reduction and other subgroups (Fig. 5).

2- Type of anesthesia: Significant difference was found in composite complication rates between the subgroups under the random effects model (*p*=0.04). This suggests that significantly lower rates of complication in the general anesthesia subgroup compared to local anesthesia or "both" subgroups (Fig. 6).

3- Presence of septal fractures: Insignificant difference was found between subgroups observed under the random effects model (*p*=0.72), suggesting no impact of septal fractures on the composite complication rate.

4- Average time to procedure: Significant difference was detected in composite complication rates between the different time frames under the random effects model (*p*<0.01) (Fig. 7).

D- *Olfactory dysfunction:*

1- Reduction type: The tests for subgroup differences are not applicable because all the studies belong to the same subgroup ("closed nasal reduction ").

2- Type of anesthesia: The tests for subgroup differences are not applicable because all the studies belong to the same subgroup of anesthesia type ("NA").

3- Septal fractures. The tests for subgroup differences under the random effects model (*p*=0.81) indicate that the differences in olfactory dysfunction rates between the subgroups are not statistically significant.

4- Timing to procedure: The results show that the rates of olfactory dysfunction vary significantly among the studies, with the lowest recorded rate being 33.33% and the highest being 75.00%. The pooled rate of olfactory dysfunction under the random effect model is 41.39% with a 95% CI between 26.15 and 58.48%. The heterogeneity test results show a substantial inconsistency (I^2=68%) among the studies, indicating significant variability in the outcomes.

E- *Nasal deformities:*

1- Reduction type: There doesn't seem to be a significant difference in the rate of nasal deformity between closed nasal reduction and open nasal reduction procedures. The common effect (*p*=0.59) indicates no significant difference. This suggests that the type of reduction does not affect the rate of nasal deformities.

2- Type of anesthesia: The analysis seems to suggest that the type of anesthesia (general or local) does not significantly affect the rate of nasal deformity, though the specific rate varies among different studies.

3- Septal fractures: There was no statistically significant difference in the rate of nasal deformity between patients with a septal fracture and those without under the common effect model (p=0.37). There was no heterogeneity when assessing all studies at once (I^2=0%).

4- Average time to procedure: The test suggests that the timing post-incident does not significantly impact the rate of nasal deformity.

Risk of bias assessment:

The risk of bias for the included studies was evaluated using the Cochrane Collaboration's risk of bias tool. Most of the studies, 17 out of 19, were non-randomized controlled trials; for these, high risks of selection, performance, and detection biases were observed due to the absence of randomization.

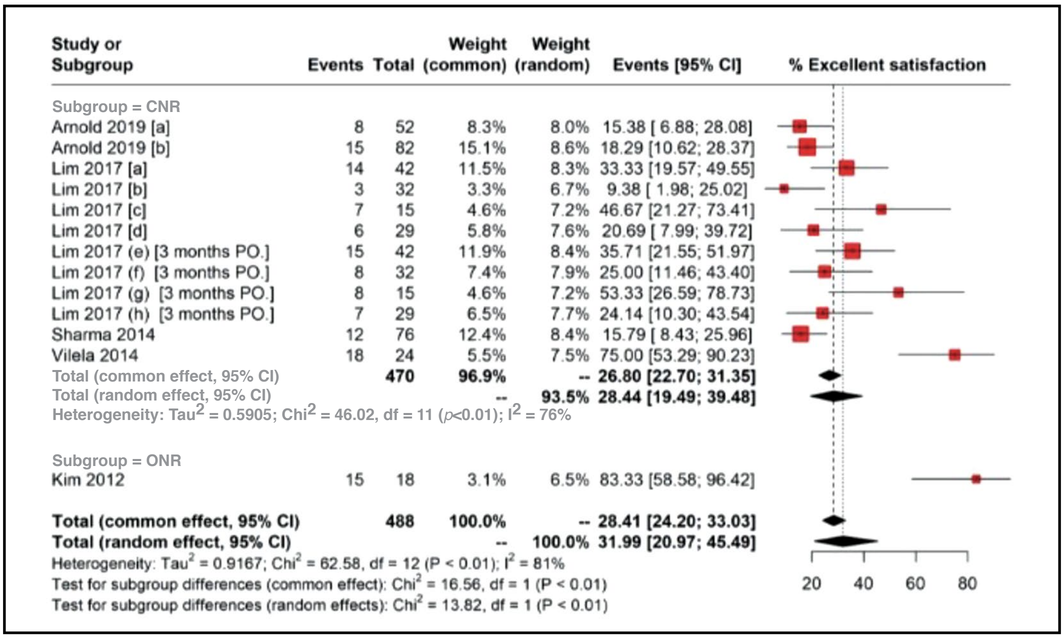

Fig. (2): Forest plot comparing the rates of excellent satisfaction among different reduction techniques. For purposes of pooling the estimates, each study arm was handled as an individual study.

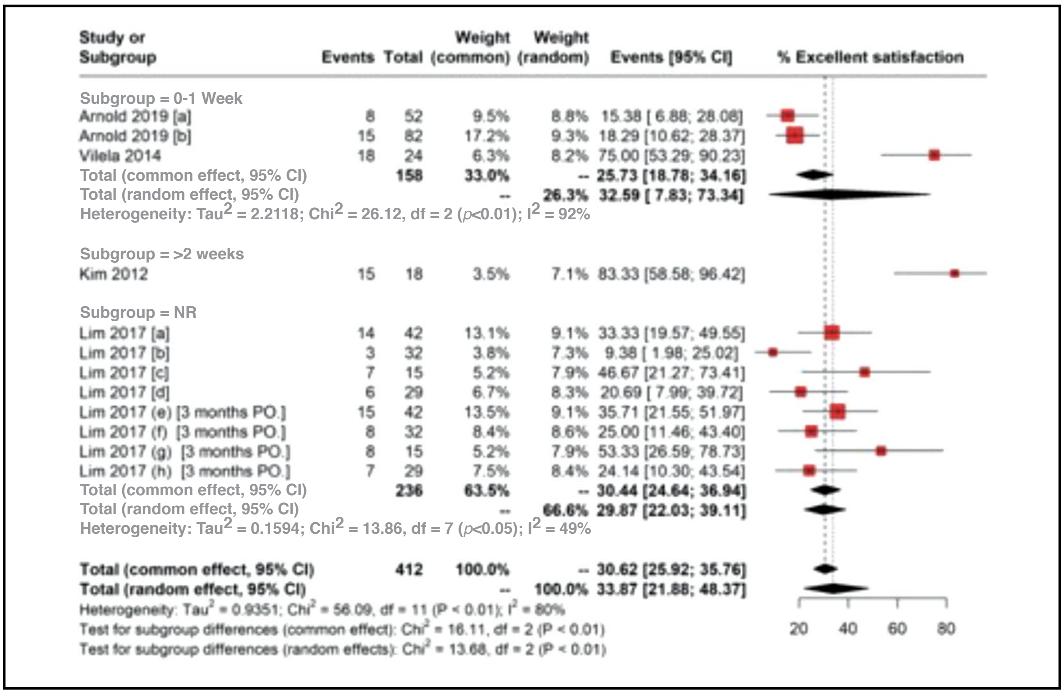

Fig. (3): Forest plot comparing the rates of excellent satisfaction among different timings of the procedure. For purposes of pooling the estimates, each study arm was handled as an individual study.

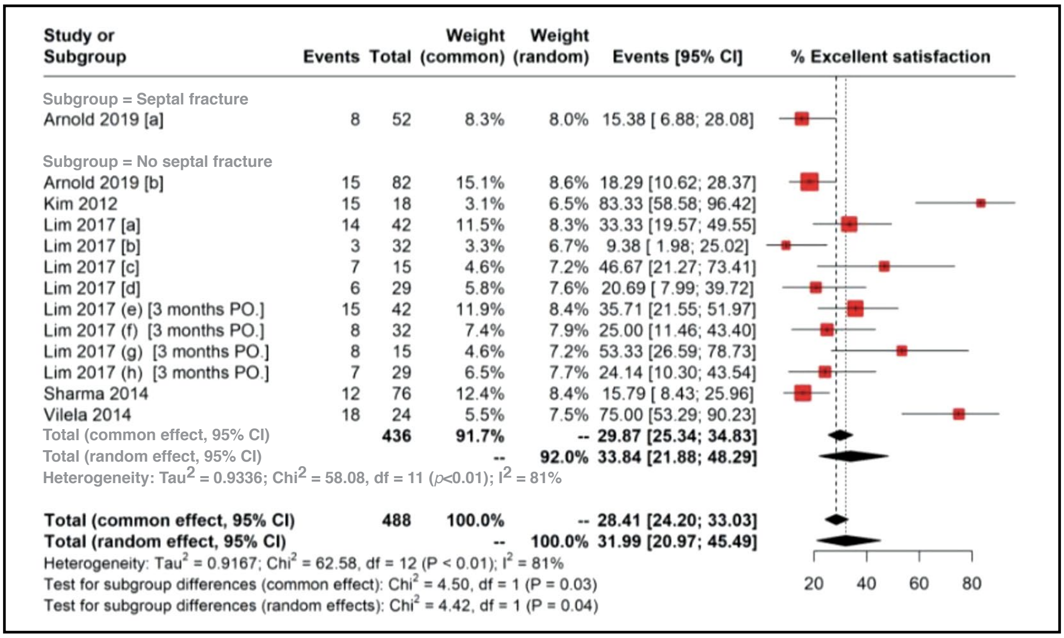

Fig. (4): Forest plot comparing the rates of excellent satisfaction based on the presence of septal fracture. For purposes of pooling the estimates, each study arm was handled as an individual study.

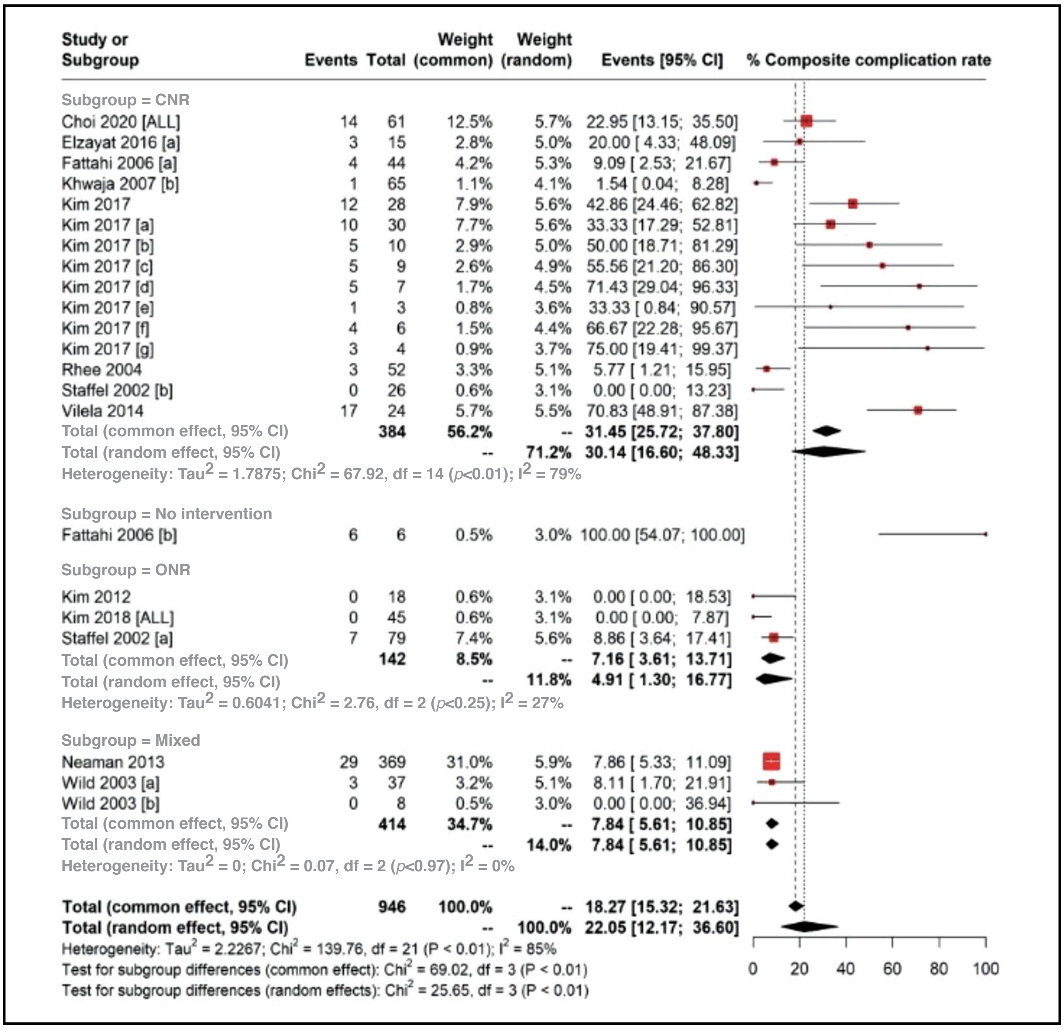

Fig. (5): Forest plot comparing the rates of composite complications based on the reduction technique. For purposes of pooling the estimates, each study arm was handled as an individual study.

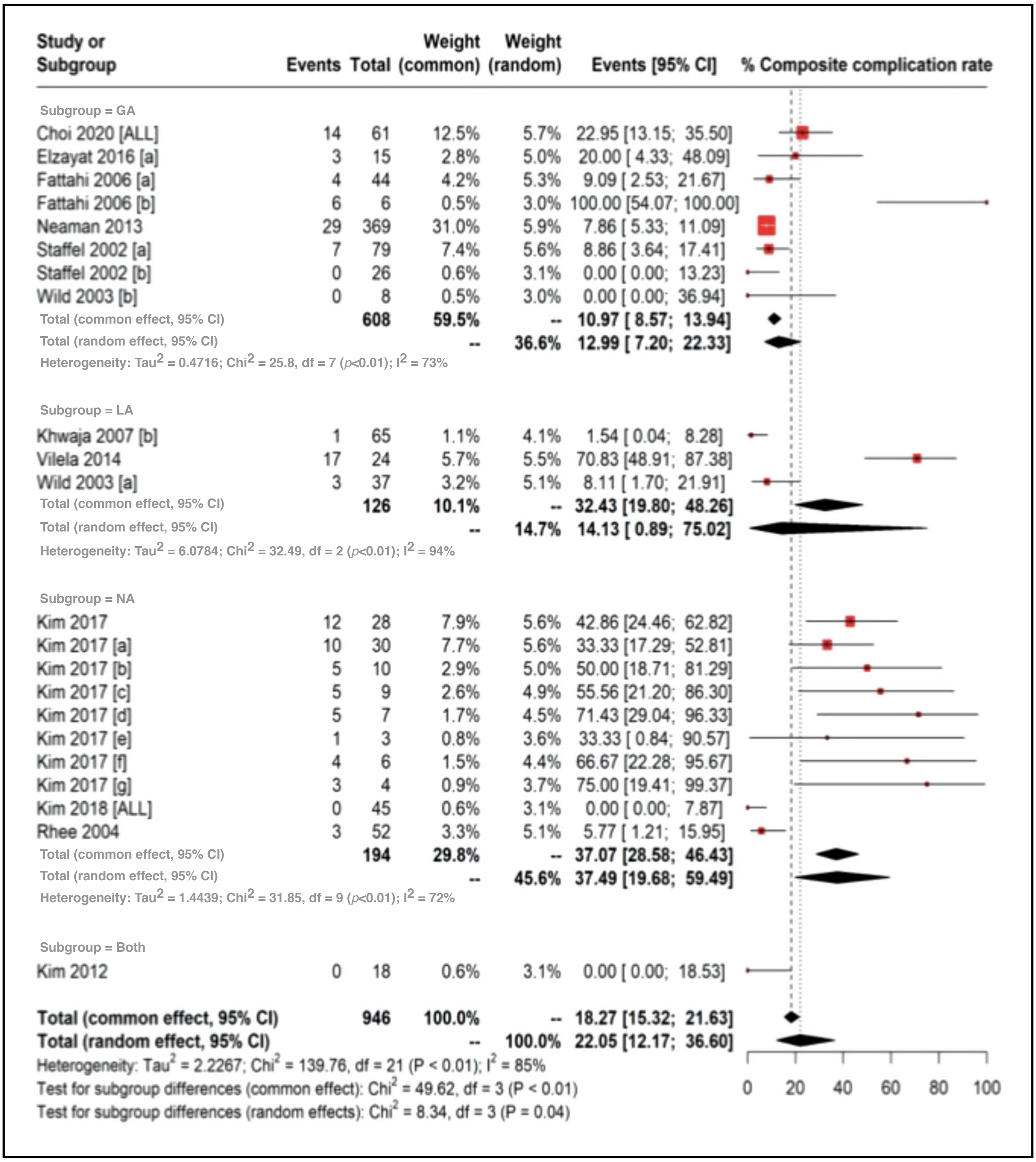

Fig. (6): Forest plot comparing the rates of composite complications based on the type of anesthesia. For purposes of pooling the estimates, each study arm was handled as an individual study.

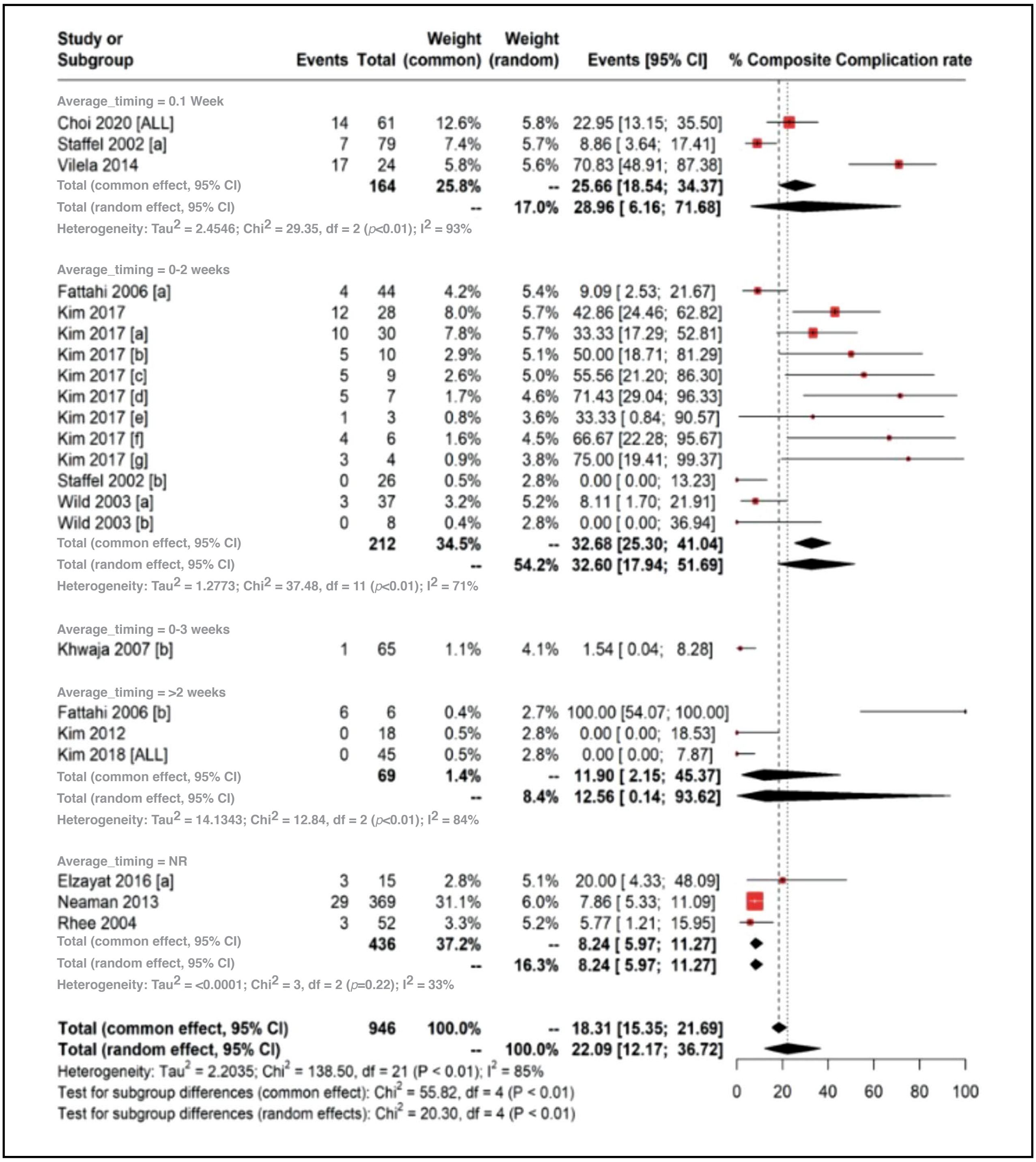

Fig. (7): Forest plot comparing the rates of composite complications based on the timing of the procedure. For purposes of pooling the estimates, each study arm was handled as an individual study.

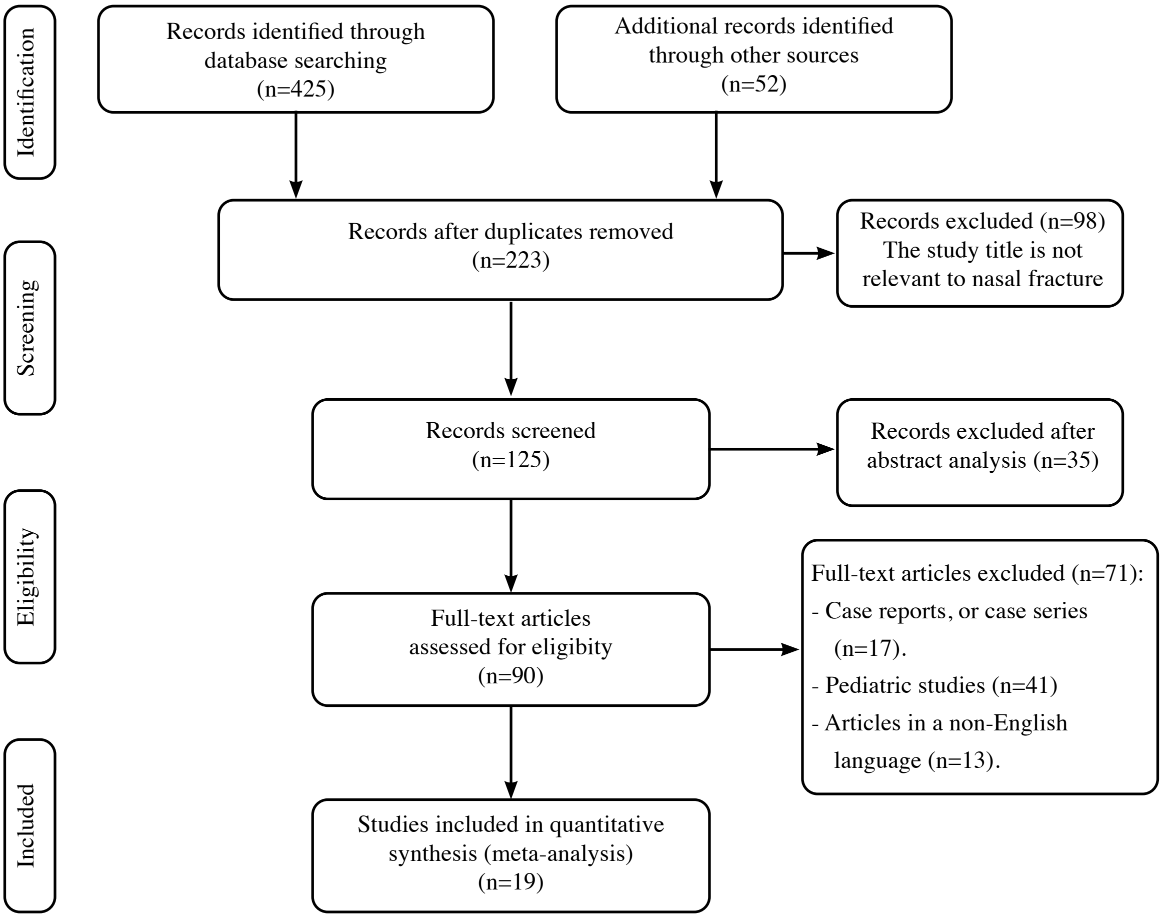

Fig. (8): Summary of the included studies.

Discussion

The primary objective of nasal fracture treatment is to restore the cosmetic appearance of the nose and normal nasal cavity function. The optimal timing, patient selection, and surgical technique for the management of nasal trauma are not yet clearly established **[8,10]**. This is due to the limited research on the topic. Some studies have suggested that early surgery (within 24 hours of injury) may be beneficial **[12]**, while others had found that late surgery may yield better results **[13]**. There is also no consensus on who should be selected for surgery, as some patients may be able to achieve satisfactory results with conservative management, such as splinting and nasal packing. The choice of surgical technique also varies depending on the severity of the injury and the patient's individual fracture **[14]**.

A systematic search of multiple databases and other sources was conducted to identify potentially relevant studies. We assessed patients' outcomes after nasal bone fracture reduction (satisfaction, revision rate, complication rates, and nasal deformities) according to four variables: Type of reduction, type of anesthesia, presence of septal fracture, and average time to procedure.

On addressing patients who emphasized they had good satisfaction; the analysis identifies the patients who underwent open nasal reduction had comparable satisfaction rates to those who underwent closed nasal reduction (p<0.01). This suggests that both procedures are effective in improving patient satisfaction. However, other studies, such as one by Kim et al. **[13]** stated that the rate of excellent satisfaction among patients who underwent open nasal reduction through an inter-cartilaginous incision was 83.33%. The data suggest that in terms of satisfaction, there was no significant difference between Local, General, or mixed anesthesia.

Younes and Elzayat, **[15]** found that septoplasty was more effective than closed septal reduction (using Ash forceps) in improving the quality-of-life outcome of patient breathing for non-comminuted septal fractures advocating for open reduction of the septum rather than closed reduction. On Assessing the effect of presence of septal fractures on overall the patient satisfaction. The time of surgical intervention was significantly associated with patient satisfaction rates ($p<0.01$). Performing closed nasal reduction within 2 weeks of trauma is associated with a higher overall satisfaction rate. In addition to the factors mentioned above, other factors that may affect patient satisfaction after nasal fracture repair include the following [5]: Severity of the nasal fracture, quality of the surgical repair, patient's expectations, the patient's personality, and patient's social support. Patients who have more severe nasal fractures may be less satisfied with the results of surgery, even if the septum is not fractured. Patients who have a poor quality of surgical repair may also be less satisfied with the results. Patients who have unrealistic expectations may also be less satisfied with the results. Patients who are more anxious or who have poor social support may also be less satisfied with the results [16].

Overall, the findings of our study suggest that type of reduction and timing to operation have a statistically significant impact on patient satisfaction while type of anesthesia and the presence of a septal fracture is not a major determinant of patient satisfaction. However, more research is needed to confirm these findings and to identify other factors that may affect patient satisfaction [7].

Corrective rhinoplasty is expensive compared with early reduction and does not guarantee positive results because of warped nasal bones and distorted nasal structures [16]. We found that both closed nasal reduction and open nasal reduction resulted in a comparable rate of revision ($p=0.65$). In contrast, Kim et al. [13] reported higher revision rates following open nasal reduction. This could be related to the fact that the studies which used open nasal reduction included severe fractures with delayed procedures, which explain the high rates of revision with open nasal reduction in his study, While Fattahi et al. [14] found that the incidence of the need for post-traumatic septo-rhinoplasty is high after closed nasal bone reduction. The composite complication rates refer to the overall rate of complications, including septal hematoma, septal abscess, avascular necrosis of the septal cartilage, rhinorrhea, and nasal obstruction (Choi et al., 2020). The findings of the study suggest that closed nasal reduction may be a safer option for patients with nasal fractures than open nasal reduction. This also may be attributed to the fact that the studies included patients with severe fractures or with delayed procedures as a candidate for open nasal reduction.

General anesthesia has higher satisfaction rates ($p<0.01$) and lower complications rates ($p=0.04$) reported by the patient when compared with local anesthesia. Olfactory dysfunction, or loss of smell, occurred due to damage to any part of the olfactory pathway. Nasal bone fractures are the most common cause of olfactory dysfunction and are typically due to a disruption of the sinus tract. The sinus tract is the pathway that odorants travel through to reach the olfactory nerve. When the sinus tract is disrupted, odorants cannot reach the olfactory nerve, resulting in olfactory dysfunction [7]. Almost half (46.4%) of nasal fracture patients experience post-traumatic olfactory dysfunction. Closed reduction of these fractures does not lead to improvements olfaction at 6 months [7].

No difference was detected in olfactory disfunction based on the reduction type. This suggests that olfactory dysfunction is probably due to factors other than the fracture itself. Moreover, the data suggests no difference in the rate of composite complications and olfactory complications based on the presence or absence of septal fractures. In contrast to Staffel [11]; Kim et al. [13] who advocated that repairing the septum at the time of closed reduction has improved the results in certain cases. Postoperative deformities are frequent sequelae of nasal bone fractures including crooked nose, saddle nose, and inverted-V deformity [17,18].

Although there is a statistical trend appears in the forest chart with apparent lower rates of deformities among the group of open nasal bone reduction compared with the closed nasal bone reduction group, no statistically significant difference was detected. Khwaja et al. [19] suggested that in the presence of a minor nasal bony deviation, with no associated septal or tip displacement, a closed nasal fracture reduction under local anesthesia should be the first line of management. If there is deviation of the nasal septum or tip associated with a bony deviation, then these factors need to be addressed to improve the likelihood of a successful surgical outcome.

The timing from the incident, till nasal reduction, does not significantly impact the rate of nasal deformity. According to data retrieved from this data, one may suggest that type of reduction or type of nasal bone fracture has a closer relation to the resultant deformities. Some experts recommend reducing the fractures within 6 hours of the injury before significant swelling sets in. Others recommend waiting 3 to 4 days, after the swelling has subsided, to get a better view of the fracture. Moreover, other authors recommend reducing nasal fractures within 10 days of the injury [19]. Data found no statistically significant difference in outcomes between early and delayed surgical intervention. This suggests that delayed surgical intervention is not necessarily superior to early surgical intervention for the treatment of nasal bone fractures [12].

Conclusion:

The optimal treatment for a patient with a nasal fracture varies depending on the individual patient's circumstances. Open nasal reduction (ONR) has a higher patient satisfaction rate, however, closed nasal reduction may be a safer option. Patients with septal fractures were less satisfied with their nasal fracture reduction outcomes, suggesting that septal fractures have a negative impact on patient satisfaction. General anesthesia has higher satisfaction rates and lower complications rates reported by the patient when compared with local anesthesia. A longer time between injury and surgery may be associated with decreased patient satisfaction, and early surgical intervention within 2 weeks of trauma is therefore recommended.

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