Systematic Review and Meta-Analysis

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Nasal protection strategy reduces the incidence of nasal pressure injuries during nasotracheal intubation

Meta-analysis with trial sequential analysis

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Abstract

Background: Nasal pressure injury is a serious problem during nasotracheal intubation. We performed this systematic review and meta-analysis to determine whether use of a nasal protection strategy (a protective dressing or a modified fixation method for the tracheal tube) reduces the incidence of nasal pressure injury during nasotracheal intubation.

Methods: Literature searches were performed using three electronic databases. Data from each of the eligible trials were combined, and calculations were made using DerSimonian and Laird random effects models. The pooled effect estimates for nasal pressure injury were evaluated using the relative risk and 95% confidence interval, the Cochrane Q statistic, and the I^2 statistic. We also performed trial sequential analysis (TSA) to assess sensitivity to prevent type I error. We separated patients into subgroups to analyze the incidence of nasal pressure injury according to whether a protective dressing or a modified fixation method for the tracheal tube was used.

Results: The literature search yielded five eligible trials. Meta-analysis of these trials showed that a nasal protection strategy significantly reduced the incidence of nasal pressure injury during nasotracheal intubation (relative risk (RR) 0.34; 95% confidence interval (CI) 0.21–0.56; $P < .0001$; Cochrane's Q = 5.86, $I^2 = 32\%$). The TSA boundary for futility could not be calculated because of an insufficient sample size. In subgroup analysis, both methods significantly reduced the incidence of nasal pressure injury during nasotracheal intubation.

Conclusions: The findings of this meta-analysis suggest that a nasal protection strategy significantly reduces the incidence of nasal pressure injury during nasotracheal intubation. During nasotracheal intubation, the use of a protective dressing or modified fixation method for the tracheal tube can prevent to the incidence of nasal pressure injuries. However, the number of samples in our meta-analysis was too small for TSA and further studies are required.

Trials registration: PROSPERO (International Prospective Register of Systematic Reviews; registration number 252091).

Abbreviations: CI = confidence interval, GRADE = Grading of Recommendations Assessment, Development and Evaluation, ICU = intensive care unit, MEDLINE = Medical Literature Analysis and Retrieval System On-Line, PICO = Population, Intervention, Comparison, Outcome, PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analyses, PROSPERO = International Prospective Register of Systematic Reviews, RR = relative risk, TSA = trial sequential analysis.

Keywords: fixation of the tracheal tube, meta-analysis, nasal pressure injury, nasal protection strategy, protective dressing

1. Introduction

Nasotracheal intubation is mainly used to secure the airway for oral or head and neck surgery and for management during long-term mechanical ventilation. Nasotracheal intubation is convenient when used for oral surgery because the tracheal tube does not occupy the oral cavity but often causes damage from the nasal tip to the columella and ala. Previous studies have found

We have no funding or conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are publicly available.

The opinions expressed herein are only those of the authors.

Our study is a meta-analysis and does not need ethical approval.

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that nasal pressure injury occurs during nasotracheal intubation in 10%–50% of cases.[1–5] Reversible redness from the nasal tip to the columella and ala is a minor problem whereas ulceration of the ala and damage to the dermis are serious complications.[6] Risk factors for nasal pressure injury during nasotracheal intubation include male sex, prolonged operating time, and long intensive care unit (ICU) stay.[3]

Generally, nasal pressure injury during nasotracheal intubation is caused by local ischemia between the nasal columella and ala as a result of the continuous pressure exerted by the tracheal tube. Nasal protection strategies, including the use of protective (hydroactive) dressings for decompression[1,3,5] and modified fixation methods for the tracheal tube, have been implemented to reduce the pressure exerted by the tube during nasotracheal intubation.[2,4]

Translational medicine is the new method and process that efficiently advance medical progress from scientists to clinicians.[7] In recent years, Translational medicine has rapidly increased its presence in the medical community, and the National Institutes of Health is also funding the project. Aiming at the concept of translational medicine, this study investigated whether nasal protection strategies (use of protective hydroactive dressings for decompression and modified fixation methods for the tracheal tube) during nasotracheal intubation prevent nasal pressure injury in clinical medical applications. Therefore, we performed a systematic review and meta-analysis to determine whether the use of a protective dressing or a modified fixation method for the tracheal tube can reduce the incidence of nasal pressure injury during nasotracheal intubation.

2. Methods

This quantitative systematic review was performed according to the criteria outlined in the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement.[8] After establishing the methods to be used for the meta-analysis and setting the inclusion and exclusion criteria, the study protocol was registered in PROSPERO (International Prospective Register of Systematic Reviews; registration number 252091).

2.1. Inclusion and exclusion criteria

Trials were included if they compared nasal pressure injury in patients who had undergone nasotracheal intubation with and without a nasal protection strategy and had a prospective randomized trial design regardless of patient age and regardless of whether the patients were managed in the operating room or ICU. Studies were excluded if a nasal cannula or nasogastric tube was used, patients were managed in the prone position, or the indication for surgery was a nasal injury. Retrospective studies, observational studies, and case reports were also excluded.

2.2. Search strategy

A comprehensive literature search was performed using MEDLINE, the Cochrane Central Register of Controlled Trials, and EMBASE through July 2021. The search strategy is shown in Supplemental S1, Supplementary Digital Content 1, http://links.lww.com/MD/H344. The reference lists of reports and reviews were also searched manually to identify further potentially eligible trials. There were no restrictions on publication language or type.

2.3. Selection of included studies

2.3.1. Data extraction. Each article was evaluated for eligibility by two of the authors (HH, TS) working independently.

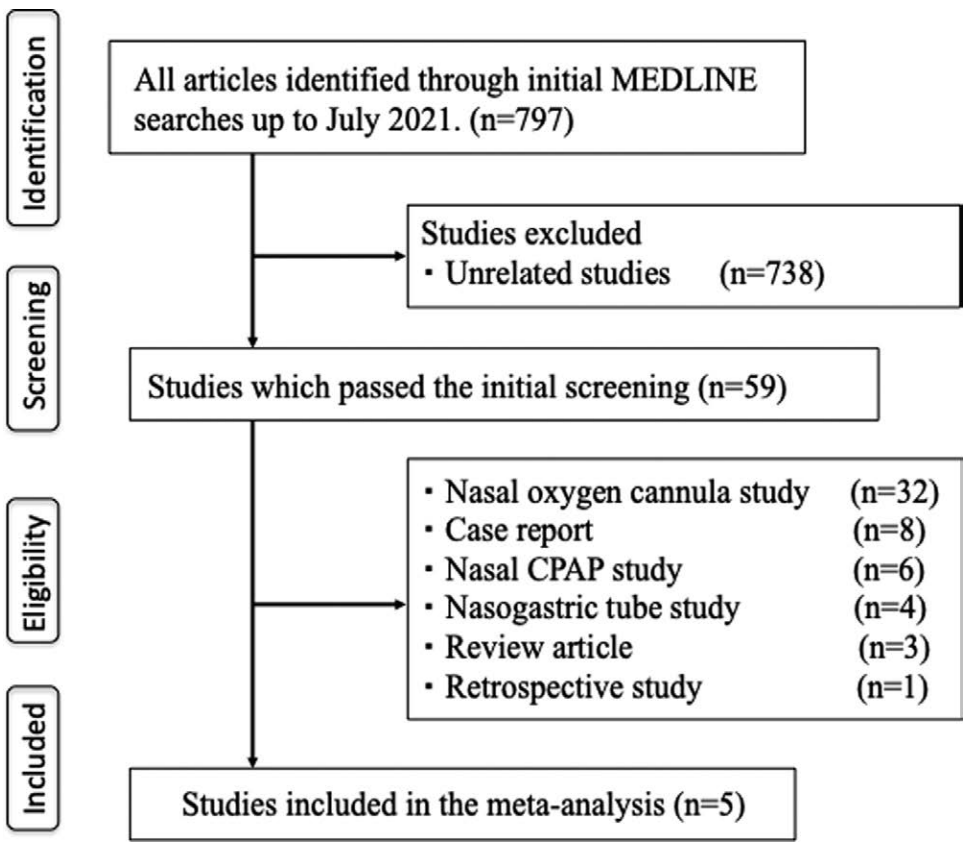

Figure 1. Meta-analysis flow chart. RCT, randomized controlled trial.

Disagreements over value or analysis assignments were resolved by discussion. Data from duplicate publications were excluded. Authors were contacted directly if a discrepancy in reported data was found. Each author used a standardized data collection form for independent data abstraction.

The primary aim of this systematic review was to determine if a nasal protection strategy could reduce the incidence of nasal pressure injury during nasotracheal intubation. We included “protective dressing (hydroactive dressing)” and “modified fixation methods for the tracheal tube” as nasal protection strategies. Modified fixation methods for the tracheal tube included not covering the nasal tip to the columella and fixing the tracheal tube to the nasal ala using tape.

The PICO elements were investigated as follows: patients managed under nasotracheal intubation (population); patients in whom received a nasal protection strategy was used (intervention); patients in whom a nasal protection strategy was not used (comparison); and presence or absence of nasal pressure injury (outcome).

In this study, a nasal pressure injury was defined as a stage 2–4 lesion according to the natural pressure ulcer advisory board score[9] and determined according to the descriptions provided in each randomized controlled trial included in the meta-analysis. We separated patients into subgroups to analyze the incidence of nasal pressure injury according to whether a protective dressing or a modified fixation method for the tracheal tube was used.

2.4. Critical appraisal of study quality

2.4.1. Risk of bias and quality of evidence assessment.

We evaluated the risk of bias with reference to the Cochrane Handbook.[10] (Supplemental S2, Supplementary Digital Content 2, http://links.lww.com/MD/H345) The Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach was used to assess the quality of evidence of the main outcomes.[11] (Supplemental S3, Supplementary Digital Content 3, http://links.lww.com/MD/H346).

2.5. Data synthesis and analysis

Data from each of the trials were combined, and calculations were performed using DerSimonian and Laird random effects models. The pooled effect estimates for nasal pressure injury were evaluated using the relative risk (RR) and 95% confidence interval (CI). The Cochrane Q and I^2 statistics, which indicate the percentage of variability due to heterogeneity rather than that due to sampling error, were used to test the homogeneity of the effect size across all trials.13 The statistical analyses were performed using Review Manager (version 5.2, Nordic Cochrane Centre, The Cochrane Collaboration, Copenhagen, Denmark). The sensitivity analysis was performed using the Hartung-Knapp-Sidik-Jonkman method, which is used when the number of studies is small (<10).[12]

We also performed a trial sequential analysis (TSA) to assess sensitivity for prevention of type I error due to multiple tests of effect in meta-analysis.[13,14] First, we calculated the required sample (information) size and set the respective risks of type I error and type II error to 5% and 10%. We set the minimum clinically meaningful odds ratio in TSA to 0.75. TSA viewer software version 0.9.5.5 beta (www.ctu.dk/tsa) was used for this analysis.

Publication bias often affects the validity of meta-analyses because studies for which the findings are not significant are often not submitted for publication. Therefore, we evaluated the potential for publication bias by generating a funnel plot with plotting of RR values against the associated standard errors[15] and used Begg’s test to assess the symmetry of the funnel plot.[16] Publication bias was considered present when the P value of

Table 1

Characteristics of included studies.

	Author	year	Number of patients (experimental/control)	Situation	Subject	Methods of nasal protection strategy	Difinition of nasal injury	Duration of intubation time
1	Onishi R	2007	27 (12/15)	ICU	Adult patients	Ingenuity in the method of fixing the tracheal tube	Epidermis peeling	N/A
2	Togami K	2013	118 (76/42)	Operation room (oral and maxillofacial surgery) AND PACU	Adult patients	Ingenuity in the method of fixing the tracheal tube	Pressure ulcer	Experimental; 23.6 h, Control; 23.2 h
3	Chen J	2020	122 (62/60)	PICU	Pediatric patients	Protect dressing (hydrocolloid)	Stage 2–4 (National pressure ulcer advisory panel in 2016)	Experimental; 116.75 h (81.5–191.81), Control; 137.5 h (37.3–198)
4	Yang G	2020	450 (225/225)	Operation room (oral and maxillofacial surgery) AND PACU	Adult patients	Protect dressing (hydrocolloid)	Stage 2–4 (National pressure ulcer advisory panel in 2016)	Operation tine, Experimental; 3.95 ± 1.2 h, Control; 3.93 ± 1.14 h, PACU, Experimental; 5.5 ± 3.14 h, Control; 5.54 ± 3.26 h
5	Sumphaongern T	2020	157 (79/78)	Operation room (oral and maxillofacial surgery)	Adult patients	Protect dressing (Hydrocolloid)	Stage 2–4 (National pressure ulcer advisory panel in 2016)	N/A

ICU = intensive care unit, PICU = pediatric intensive care unit, PACU = post-anesthesia care unit.

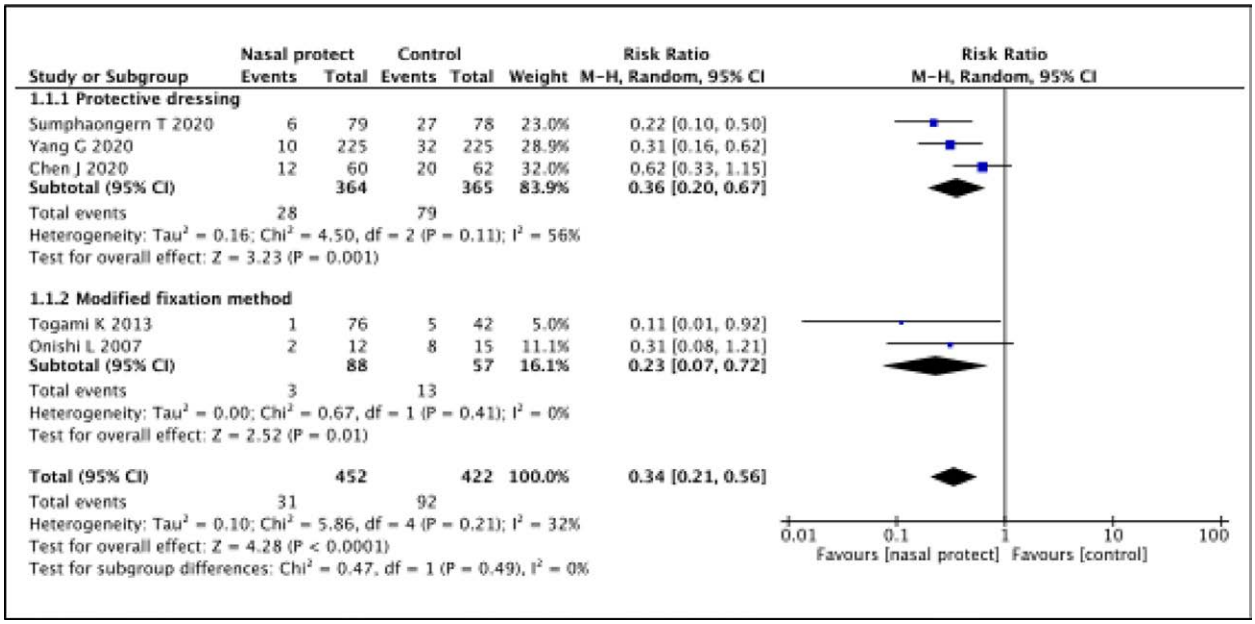

Figure 2. Forest plot of the incidence of nasal pressure injury comparing the nasal protection strategy and control.

the asymmetry test was <.1. However, we could not evaluate publication bias because the number of studies included in the analysis was <10.

3. Results

3.1. Characteristics of the included studies

The initial search of the electronic databases identified 797 potentially eligible articles, 738 of which were excluded because they were deemed to be unrelated to this research. The remaining 59 articles were examined closely to determine if the inclusion criteria were met. We excluded a further 54 studies because they reported the results of nasal oxygen cannulation (n = 32) or were case reports (n = 8), studies of nasal continuous positive airway pressure (n = 4), review articles (n = 3), or retrospective studies (n = 1) The remaining five articles contained the necessary data for the planned comparison and met the inclusion criteria, as shown in Figure 1.[1–5]

Four of the five studies were performed in adults and one in pediatric patients. Extubation was performed in the operating room, ICU, or postanesthesia care unit. The nasal protection strategy was a protective dressing in three trials and a modified fixation method for the tracheal tube in 2 trials. The definition of nasal pressure injury was different in each trial. Three of the five studies defined nasal pressure injury as a natural pressure ulcer advisory board score stage 2–4 lesion. Nasal pressure injury was defined as peeling of the epidermis in one of the remaining two trials and as a pressure ulcer in the other. Details of the selected trials are summarized in Table 1.

3.2. Results of the meta-analysis

3.2.1. Primary outcome. A nasal protection strategy was used in 452 patients and not used in 422. Meta-analysis of the five trials showed that the use of a nasal protection strategy significantly reduced the incidence of nasal pressure injury during nasotracheal intubation (RR 0.34; 95% CI 0.21–0.56; $P < .0001$; Cochrane's Q = 5.86; $I^2 = 32\%$; Fig. 2). TSA widened the CI to 0.11–1.05. The Z curve did not reach the TSA monitoring boundary for the benefit and the TSA boundary for futility could not be calculated because of the insufficient sample size; the sample size accrued (n = 874) was 23.8% of the required sample size (n = 3669) (Fig. 3).

3.2.2. Subgroup analysis. We performed a subgroup analysis of the incidence of nasal pressure injury according to whether the nasal protection strategy was a protective dressing or a modified fixation method for the tracheal tube. Both methods significantly reduced the incidence of nasal pressure injury during nasotracheal intubation (protective dressing, RR 0.36; 95% CI 0.20–0.67; $P = .001$; Cochrane's Q = 4.50; $I^2 = 56\%$; modified tracheal tube fixation method, RR 0.23; 95% CI 0.07–0.72; $P = 0.01$; Cochrane's Q = 0.67; $I^2 = 0\%$) (Fig. 2).

3.2.3. Sensitivity analysis. The sensitivity analysis was performed using the Hartung–Knapp–Sidik–Jonkman method in view of the small number of studies (<10) eligible for inclusion in the meta-analysis. The significance level was similar to that found using the results of the DerSimonian and Laird random effects model (RR 0.34; 95% CI, 0.18–0.66; $P = .01$; t-value = –4.52)

3.3. Quality of evidence

The quality of evidence was graded as very low. The articles included in this comparison had low heterogeneity. However, small-study effects could not be assessed using funnel plots because fewer than 10 studies were analyzed. Therefore, we downgraded the quality of evidence to low (Fig. 4).

3.4. Publication bias and risk of bias

Publication bias was not evaluated because of the small number of studies included in the analysis. The risk of bias is summarized in Figure 5.

4. Discussion

The findings of this meta-analysis suggest that a nasal protection strategy significantly reduces the incidence of nasal pressure injury during nasotracheal intubation. There are various risk factors for nasal pressure injury during nasal intubation, the most important of which is direct continuous pressure on the nasal tip,

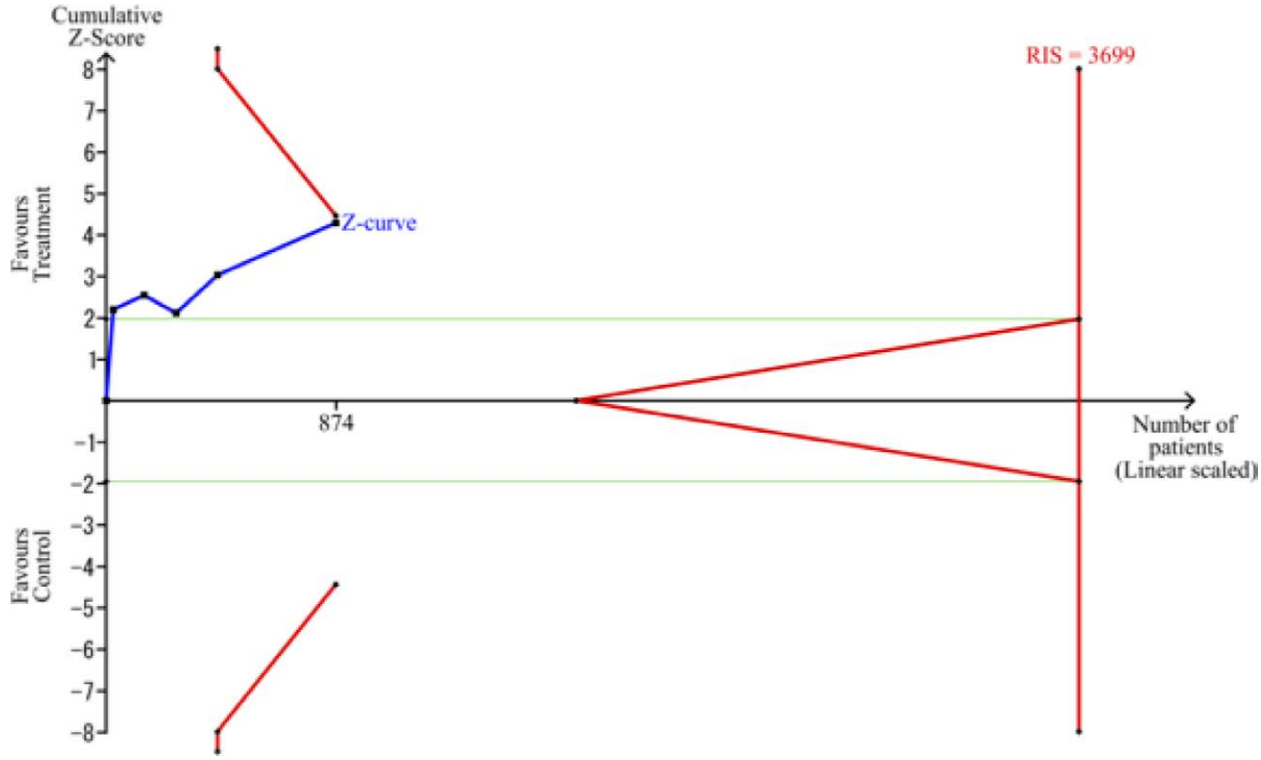

Figure 3. Trial sequential analysis for the incidence of nasal pressure injuries during nasotracheal intubation.

Summary of findings:

[Nasal protection] compared to [cContrpl] for [health problem and/or population]

Patient or population: [health problem and/or population]
Setting:
Intervention: [Nasal protection]
Comparison: [cContrpl]

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with [cContrpl]	Risk with [Nasal protection]				
Nasal protection strategy	218 per 1,000	**74 per 1,000** (46 to 122)	**RR 0.34** (0.21 to 0.56)	874 (5 RCTs)	⨁◯◯◯ VERY LOW a,b,c	

***The risk in the intervention group** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: Confidence interval; **RR:** Risk ratio

GRADE Working Group grades of evidence
High certainty: We are very confident that the true effect lies close to that of the estimate of the effect
Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Explanations

a. There was no study with low risk of bias in the overall domain.
b. TSA suggested that total sample size not reached the required information size.
c. Publication bias could not be assessed because limited number of studies (below 10) was included in each analysis.

Figure 4. The Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach.

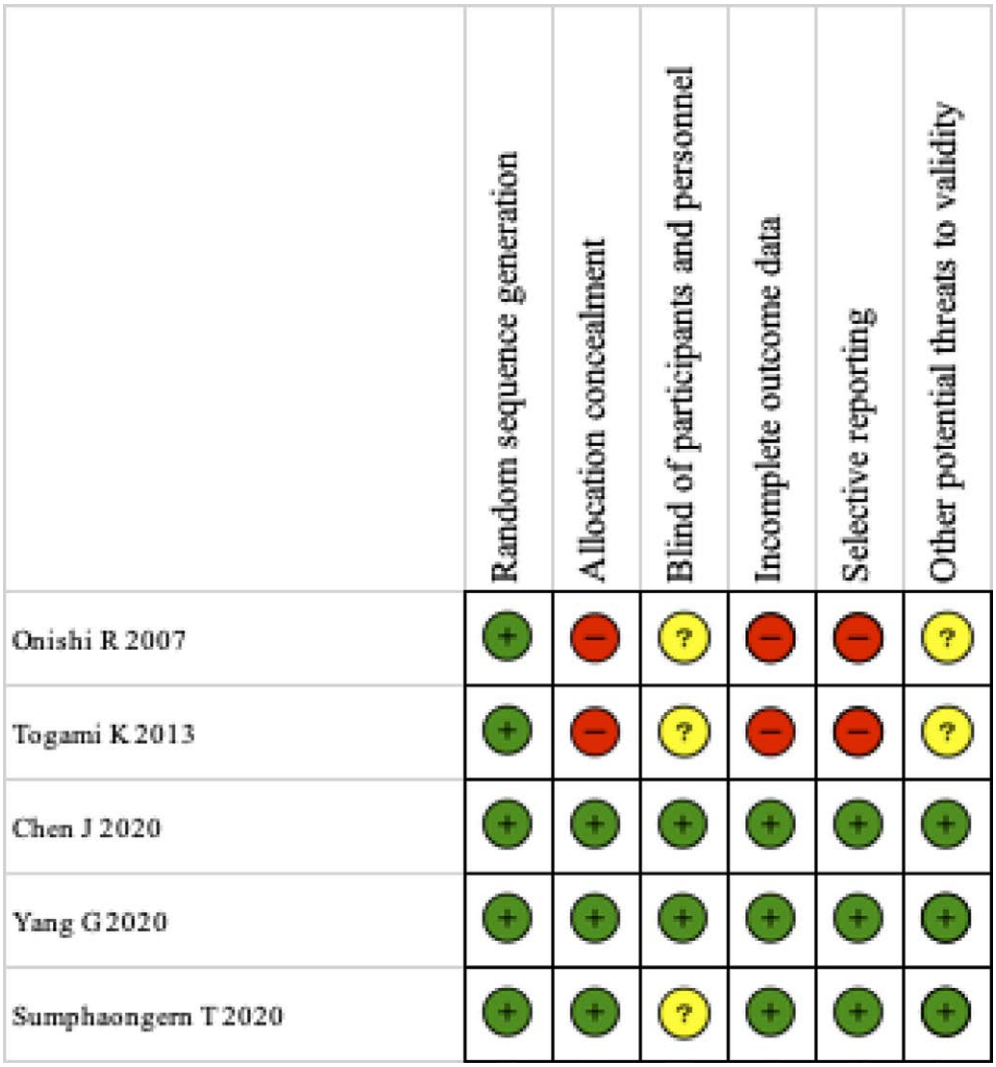

Figure 5. The risk of bias assessment. Green circles, red circles, and yellow circles indicate "low risk of bias," "high risk of bias," and "unclear risk of bias," respectively.

columella, and ala, which inhibits blood flow in the nasal tissue. In this study, a nasal protection strategy was defined as a protective dressing or a modified fixation method for the tracheal tube. Both methods decreased the risk of nasal pressure injury by reducing the pressure on the nasal tip, columella, and ala.

A variety of dressings can be used to protect the nose; however, this meta-analysis included only studies that used hydrocolloid dressings.[3] Generally, hydrocolloid dressings are used for wounds such as pressure ulcers and are composed of a hydrocolloid matrix bonded to a vapor-permeable film or foam backing.[17] The main functions of hydrocolloid dressings are wound protection, maintenance of a moist environment, absorption of exudate, suppression of infection, and pain relief. Our present findings suggest that hydrocolloid dressings reduce the incidence of nasal pressure injury mainly by reducing the pressure exerted by the tracheal tube on the nose. However, maintenance of a moist environment and suppression of infection may also help to reduce the incidence of nasal pressure injury.

In subgroup analysis, the use of a modified fixation method for the tracheal tube significantly reduced the incidence of nasal pressure injury during nasotracheal intubation. In this meta-analysis, we compared the outcomes of using and not using a modified fixation method for the tracheal tube and using or not using a protective dressing to cover the nasal tip, columella, and ala. A method that does not involve covering the nasal tip avoids pressure on the nose and does not cause nasal pressure injury. However, the strength of fixation of the tracheal tube is reduced when using this method and there is a risk that the tracheal tube will be dislodged. Therefore, this method is likely to be unsuitable for surgery that involves movement of the head or prolonged operating times.

There have been other reports on the use of a nasal protection strategy to prevent nasal pressure injury in addition to those included in our meta-analysis. For example, there has been a report on how to improve fixation of the tracheal tube so that it does not exert pressure on the nasal tip or columella.[18] Research is also underway to determine if changing the type of tracheal tube can prevent nasal pressure injury.[19] However, no conclusions have been reached as to whether these methods can prevent nasal pressure injury, and further studies are needed.

4.1. Limitation

This study lacked the sample size required for a meta-analysis to produce accurate results. The number of eligible studies was too small to be able to evaluate publication bias, which resulted in lowering the GRADE assessment. Furthermore, we could not assess the effect of combining the use of a protective dressing and a modified fixation method for the tracheal

tube on the incidence of nasal pressure injury. Further research is needed to determine the protective effect of a combination of these two methods. Moreover, patient background factors (e.g., age), duration of intubation, and the thickness and type of tracheal tube used varied from study to study. These differences are potential sources of bias in a meta-analysis.

4.2. Conclusions

The findings of this meta-analysis suggest that the use of a nasal protection strategy significantly reduces the risk of a nasal pressure injury during nasotracheal intubation. During nasotracheal intubation, the use of a protective dressing or modified fixation method for the tracheal tube can prevent to the incidence of nasal pressure injuries. However, the number of samples in our meta-analysis was too small for TSA and further research is needed.

Author contributions

H.H. and T.S. had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: H.H., T.S., K.M.
Acquisition, analysis, or interpretation of data: H.H., T.M., T.N., T.S.
Drafting of manuscript: H.H., A.S., K.M.
Critical revision of the manuscript for important intellectual content: H.H., T.N., A.S., T.M.
Statistical analysis: H.H., T.M., T.S.
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Administrative, technical, or material support: H.H., K.M.
Supervision: H.H., A.S., T.S.

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