Is postoperative nasal packing after septoplasty safe? A systematic review and meta-analysis of randomized controlled studies*

Chernkwan K. Titirungruang, Natamon Charakorn, Busarakum Chaitusaney, Prakobkiat Hirunwiwatkul

Department of Otolaryngology, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand

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Abstract

Objectives: To systemically review and compare post-septoplasty complications between total nasal packing and other techniques.

Methodology: We searched electronic databases (PubMed, Scopus, and Cochrane Library) and additional sources. The most recent search was on November 30th, 2020. Randomized controlled trials (RCTs) comparing adverse events after post-septoplasty nasal packing versus other techniques were included. The outcomes were adverse events, including respiratory distress, oxygen desaturation, pain severity, bleeding, hematoma, sleep disturbance, infection, crusting, epiphora, dysphagia, perforation, adhesion, and residual septal deviation.

Results: There were 47 studies (4,087 participants) in this systematic review. Nasal packing was more likely to cause adverse events than other techniques. There were significant increases in respiratory distress, pain, sleep disturbance, crusting, epiphora, dysphagia, and adhesion. There were no statistically significant differences in oxygen desaturation, bleeding, hematoma, infection, perforation, and residual septal deviation. Subgroup analysis found that trans-septal suture was less likely to cause post-operative complications compared with total nasal packing.

Conclusion: Nasal packing after septoplasty was more likely to cause adverse events, including respiratory distress, pain, sleep disturbance, crusting, epiphora, dysphagia, and adhesion. Furthermore, there were no benefits of nasal packing in preventing bleeding, hematoma, and residual septal deviation when compared with other techniques. Routine nasal packing after septoplasty should be avoided. Trans-septal suture should be considered instead.

Key words: complication, meta-analysis, nasal packing, septoplasty, trans-septal suture

Introduction

Septoplasty is a common procedure for treating nasal obstruction caused by nasal septal deviation. Traditionally, bilateral anterior nasal packing is performed following septoplasty to prevent bleeding, septal hematoma, and adhesion between the septum and lateral nasal wall. Furthermore, it is thought to reduce the risk of residual septal deviation by stabilizing the remaining septum during the healing process[1]. However, totally occlusive nasal packing has a tendency to cause adverse events, including respiratory distress, pain, infection, sleep disturbance, crusting, epiphora, and dysphagia. The routine nasal packing after septoplasty has been questioned in the past decades. Many post-operative techniques have been introduced as alternatives to the nasal packing, such as trans-septal suturing, nasal splinting, trans-septal stapling, and inter-septal fibrin glue, etc. Trans-septal suture technique has been promoted since the 1980s and currently is the most widely used. This procedure is used to prevent the formation of septal hematoma, close the tear mucosa, and support the remaining cartilage[2]. However, tight trans-septal sutures can increase the risk of septal perfo-

ration[1]. Intranasal septal splints are also used as an alternative to nasal packing to decrease bleeding, prevent adhesion, and stabilize the remaining septum[3].

Previous meta-analyses compared the risks of post-septoplasty complications between nasal packing and trans-septal suture. There were no significant differences in the risks of bleeding, hematoma, perforation, and residual septal deviation[4-7], while the risks of adhesion, and infection were inconclusive[4-7]. Trans-septal suture significantly decreased postoperative pain compared to the nasal packing[5-7]. Nasal splinting was also analyzed in 2 meta-analyses which included both trans-septal suture and nasal splinting in the non-packing intervention. However, the subgroup analysis of nasal splinting was not done[4,6]. A meta-analysis by Banglawala et al., which included 2 randomized controlled trials (RCTs) and 12 observational studies found that post-septoplasty nasal packing did not seem to cause adverse cardiopulmonary changes[8].

There are many RCTs that have not been included in the previous meta-analyses. In addition, many adverse events caused by post-septoplasty nasal packing have not been analyzed, especially respiratory distress, which could cause a serious morbidity and prolong hospitalization. This meta-analysis aimed to systemically review and compare post-operative complications between the post-septoplasty total nasal packing and other techniques.

Materials and methods

Information sources and search strategy

Three authors (CKT, NC, and BC) independently conducted searches for published, unpublished, and ongoing RCTs from electronic databases, via PubMed, Scopus, and the Cochrane library. The search began on November 15th, and the most recent search was on November 30th, 2020. The search terms were "(septoplasty OR (nasal septum surgery)) AND ((nasal packing) OR (trans-septal suture) OR (nasal splint))." We manually searched other sources from the Chulalongkorn Medical Library and those existing primary researches in previous meta-analyses.

Study selection

The inclusion criteria were RCTs relating to: 1) patients in all age groups who underwent septoplasty with or without turbinoplasty, 2) comparisons between post-operative nasal packing and other techniques, 3) at least one of the following post-operative outcome measures: respiratory distress, oxygen desaturation, pain severity, bleeding, hematoma, sleep disturbance, infection, crusting, epiphora, dysphagia, perforation, adhesion, and residual septal deviation, and 4) published in any language. Articles with the following exclusion criteria were eliminated if: 1) the patients underwent additional nasal surgery other than septoplasty and turbinoplasty 2) the reported data were incorrect or incomplete that could not provide outcome measures, and 3) repeated published literature.

Three authors (CKT, NC, and BC) independently reviewed titles and abstracts of the articles and selected the articles that met the selection criteria. Full-text of the selected articles were reviewed. The articles in other languages were translated. If there was any insufficient data, the corresponding author of that article was contacted for further information. Discrepancies were resolved by discussion among the authors or the decision of the fourth author (PH).

Quality assessment

Three authors (CKT, NC, and BC) independently evaluated quality of the included studies by assessing the risks of bias in accordance with the Cochrane Handbook for Systematic Reviews of Interventions Version 6.1. Risk of bias in each study was assessed in the following domains: selection bias, performance bias, detection bias, attrition bias, and reporting bias. Each domain was classified as low risk, high risk, or unclear risk. Low risk or high risk of bias was determined if the described methods met the criteria of low risk of bias or high risk of bias of that domain, respectively. Unclear risk of bias was selected when there was either a lack of information or uncertainty over the potential for bias. Discrepancies were resolved by discussion or through a fourth investigator (PH).

Data extraction

Two authors (CKT and NC) independently extracted and recorded the data. The extracted data were age of the patient, type of anesthesia, nasal packing materials, nasal packing duration, other techniques, follow-up time, and adverse events as follows: respiratory distress, oxygen saturation, pain severity score, bleeding, hematoma, sleep disturbance events, sleep disturbance score, infection, crusting, epiphora, dysphagia, perforation, adhesion, and residual septal deviation.

Statistical analysis

Data were pooled for meta-analysis. Subgroup analyses by alternative technique were performed. Odds ratio (OR) and 95% confidence interval (CI) were used for dichotomous data. Continuous data were presented as mean difference (MD) or standardized mean difference (SMD), standard deviation (SD) and 95% CI. The standard error, median, range, or 95% CI was imputed if the SD was not reported. Discrepancies in treatment effects among different trials were assessed using a heterogeneity (I2) statistic. An I2 of <40%, 40-60% and >60% represented low, moderate and substantial heterogeneity, respectively. When a heterogeneity was low, a fixed-effect model was used. A random effects model was used if a heterogeneity was high for a more conservative estimate of the differences. All statistical assessments were conducted using the Review Manager 5.4 software. Sensitivity analyses were performed based the following: high

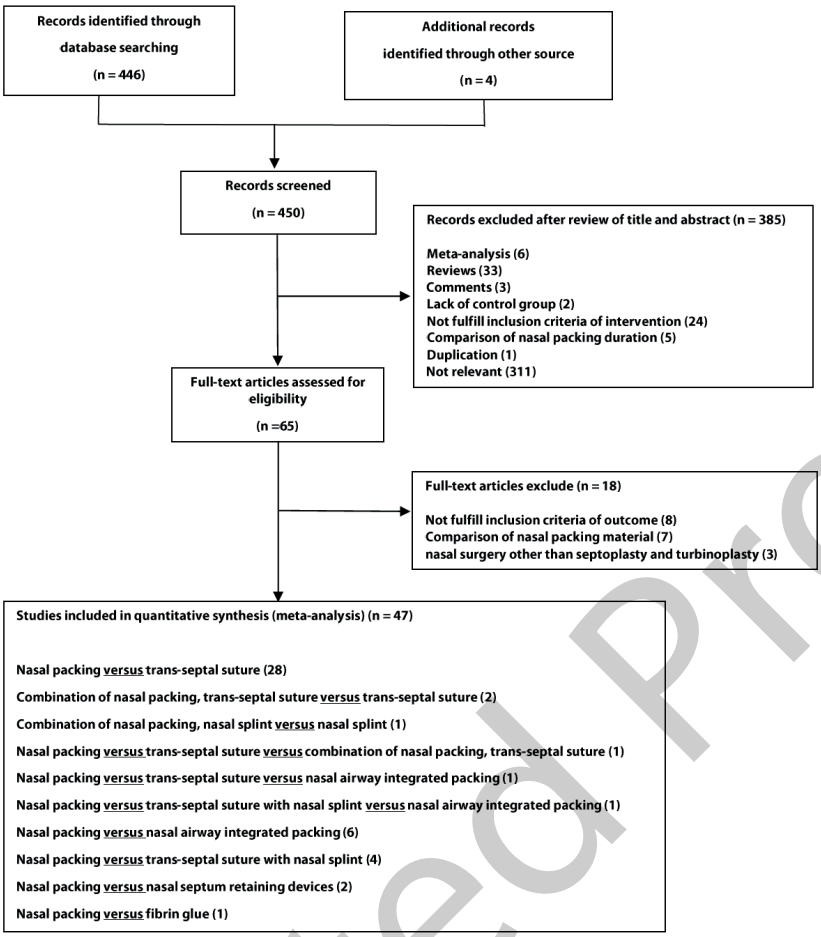

Figure 1. PRISMA flow diagram of study searching strategy

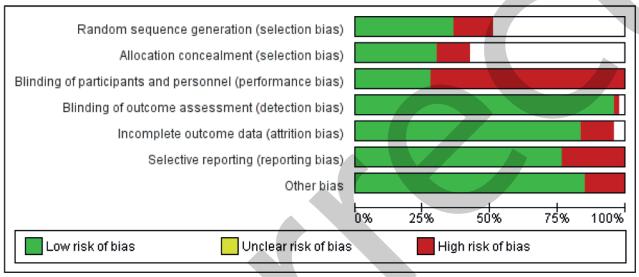

Figure 2. Quality assessment summary for included studies: risk of bias graph.

methodological quality study, exclusion of studies that caused heterogeneity, and exclusion of studies with different pain score systems.

Results

Study selection

A total of 450 references were retrieved. After the titles and abstracts were reviewed, 385 studies were excluded from the study. Full-text of the remaining 65 RCTs were reviewed, 47 of which met the selection criteria and were included in this meta-analysis (Figure 1).

A; Random sequence generation (Selection bias), B; Allocation concealment (Selection bias), C; Blinding of participants and personnel (Performance bias), D; Blinding of outcome assessment (Detection bias), E; Incomplete outcome data (Attrition bias), F; Selective report (Reporting bias), G; Other bias

Figure 3. Methodology quality assessment for each included study.

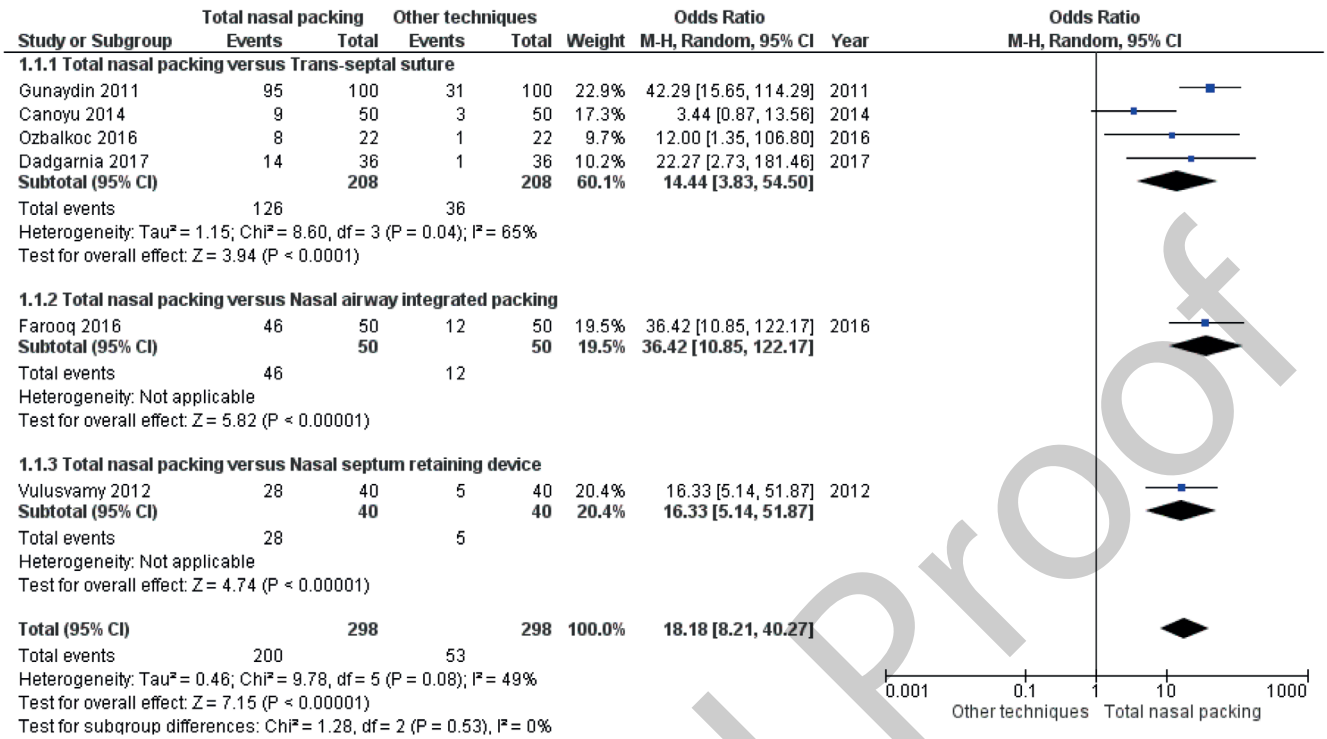

Figure 4. Respiratory distress, odds ratio (OR), Total nasal packing versus other techniques: random-effect model.

Quality assessment

Quality of the included studies was evaluated and presented in Figure 2 and Figure 3. About 30% of the included studies had low risk of randomization and 25% had adequate concealment of allocations. Most of the studies had unclear risk of selection bias because the randomization and concealment of allocations were not mentioned in the methods. Seventy-five percent of the studies had high risk of performance bias due to lack of blinding of the participants which may influence the subjective outcomes such as sleep disturbance and pain severity. Most studies had no detection bias because the outcome measurements were not influenced by lack of blinding of the outcome assessors. Thirteen percent of the included studies had high risk of attrition bias due to a large proportion of drop-out participants without explanation. Two studies did not mention the missing data. Twenty-five percent of the included studies had reporting bias. Eight studies did not report complete statistical data of pain score. Three studies did not report numeric data of complication events, which were sleep disturbance, hematoma, and crusting. Six studies had "other bias" because these studies did not use visual analog scale (VAS) 0-10 for pain severity measurement.

Characteristics of the included studies

Forty-seven studies (4,087 participants) were included in this meta-analysis [9-55]. There were comparisons of nasal packing versus: trans-septal suture (28 studies), trans-septal suture with nasal splint (4 studies), nasal airway integrated packing (6 studies), nasal septum retaining devices (nasal clip in one study and invented nasal retaining device in one study), and inter-septal fibrin glue (1 study).The combination of nasal packing and trans-septal suture was compared with trans-septal suture (2 studies) and the combination of nasal packing and nasal splint was compared with nasal splint (1 study). There were 3-arm intervention studies that compared nasal packing versus: 1) trans-septal suture (the second arm) and the combination of nasal packing and trans-septal suture (the third arm,1 study), 2) trans-septal suture (the second arm) and nasal airway integrated packing (the third arm,1 study), 3) nasal splint (the second arm) and nasal airway integrated packing (the third arm, 1 study). Forty studies were published in English and 7 studies were published in other languages which were Chinese, and Turkish. Forty-five studies were conducted in adult and 2 studies did not mention the age of participants. Characteristics of the included studies are shown in Table 1.

Effects of interventions

A summary of post-operative complications of nasal packing compared with other techniques is presented in Table 2.

Respiratory distress

Six studies (596 participants) were included in this analysis. The total nasal packing significantly increased the odds of respiratory distress events compared to other procedures (OR 18.18;

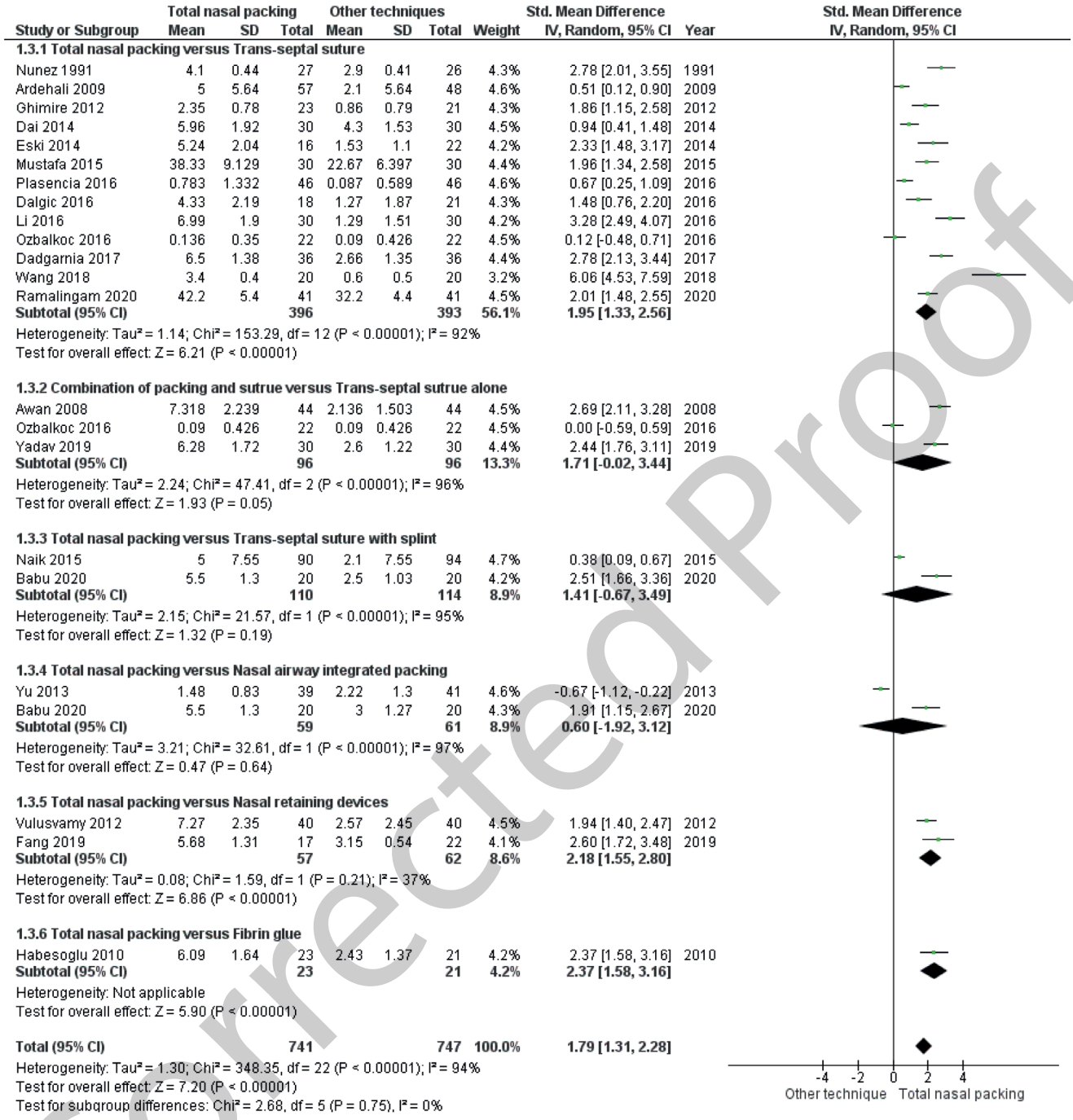

Figure 5. Pain score, Standardized mean difference (SMD), Total nasal packing versus other techniques: random-effect model.

95% CI 8.21–40.27; p < 0.001). The heterogeneity was moderate (I2 = 49%; p= 0.08). The results are shown in Table 2 and Figure 4. The definition of respiratory distress was different among these six studies. A summary of respiratory distress definition among the included studies is presented in Table 3.

Oxygen desaturation

Six studies (319 participants) were included in this analysis. There was no statistically significant difference between the total nasal packing and other procedures (MD -2.01; 95% CI -4.03 to 0.01; p= 0.05). The heterogeneity was high (I2 = 98%; p < 0.001). The forest plot is shown in the electronic supplement (e-Figure 1).

Pain

Twenty-one studies (1,488 participants) were included in this analysis. The pain in the total nasal packing group was significantly worse than other procedures (SMD 1.79; 95% CI 1.31-2.28;

Table 1. Characteristics of included studies.

Authors	Year	Sample size		Age (years)	TOA	Packing intervention†	Other intervention†	Follow up†	Outcome											
		pack	Oth						RD	O2	SL	P	Inf	Cr	Epi	Dp	Pf	BL	He	Ad	rD
Total nasal packing versus Trans-septal suture																					
Ramalingam[9]	2020	41	41	>20	GA	Merocel, 24h	Vicryl 3-0	2w			+	+		+	+				+	+	
Wang[10]	2018	20	20	N/A	GA	Ivalon,3d	vicryl 4-0, 5d	1w			+		+		+	+	+	+	+	+	+
Dadgarnia[11]	2017	36	36	adults	N/A	ribbon gauze	vicryl 3-0 or 4-0	3m	+						+			+	+	+	+
Plasencia[12]	2016	46	46	18-76	GA	Merocel, 3 d	Vicryl 3-0	3m				+						+			
Li[13]	2016	30	30	19-45	GA	polymer expansion sponge, 24h	Suture (N/A), remove 7d	7d			+	+	+		+	+	+		+	+	
Dalgic[14]	2016	18	21	17-55	N/A	Merocel, 48h	suture (N/A)	48h				+									
Shao[15]	2016	79	79	18-64	N/A	Merocel, 2d	suture (N/A)	12m					+				+		+	+	+
Mustafa[16]	2015	30	30	18-45	GA	merocel with tetracycline ointment, 1d	Vicryl 4-0	1m			+	+			+	+	+		+	+	
Cayonu[17]	2014	50	50	18-54	GA	Merocel, 48h	Vicryl 3-0 (2-4 stitched)	3m	+				+				+	+	+	+	
Dai[18]	2014	30	30	17-67	N/A	polymer hemostatic sponge, 24h	absorbable thread 5-0	1w					+				+		+	+	+
Eski[19]	2014	16	22	18-61	GA	merocel with nitrofurazone ointment, 48h	Vicryl 4-0 (3-6 stitches)	3m				+						+	+	+	
Okris[20]	2013	50	50	18-61	GA	Merocel, 48h	Vicryl4-0	3m				+	+				+		+	+	
Turhan[21]	2013	23	20	20-30	N/A	Merocel, 3d	Vicryl 4-0	1d		+											
Yang[22]	2013	30	30	18-64	N/A	Merocel, 2d	suture (N/A)	1wk					+				+	+	+	+	+
Cukurova[23]	2012	334	363	17-72	GA, LA	Merocel, 48h	vicryl 4-0	7d									+		+	+	
Ghimire[24]	2012	23	21	10-50	GA	ribbon gauze with antibiotics	suture (N/A)	1mo				+					+	+		+	+
Gunaydin[25]	2011	100	100	16-55	GA	Merocel, 48h	Vicryl 3-0, 4-0	5mo		+		+	+	+			+	+	+		
Naghibzadeh[26]	2011	77	68	15-63	GA	tetracycline-impregnant gauze, 24-48h	Vicryl 5-0	12m						+			+	+	+	+	
Thapa[27]	2011	41	46	13-52	GA, LA	ribbin gauze soak by BIPP + soframycin, 48 h	Vicryl 3-0	2m					+	+				+		+	
Wang[28]	2011	40	40	Mean 36	N/A	Merocel, 2d	Vicryl 4-0, Wormald's continuous suture	N/A									+		+	+	+
Korkut[29]	2010	27	37	19-62	GA	Netcell 5000, 48 hr	Vicryl 4-0 multiple random throws	3m			+		+		+	+	+	+	+	+	
Kula[30]	2010	15	18	18-61	GA	Fingerstall filled with gauze, smeared with vasline, 28 h	Chromic cat gut4-0	6w					+				+				+

Table 1 continued.

Authors	Year	Sample size		Age (years)	TOA	Packing intervention†	Other intervention†	Follow up†	Outcome											
		pack	Oth						RD	O2	SL	P	Inf	Cr	Epi	Dp	Pf	BL	He	Ad	rD
Ardehali[31]	2009	57	28	mean 24.6	N/A	tetracycline-soaked mesh with nasal splint, 48 h	Vicryl 4-0 (4 horizontal mattress stitches)	12m				+	+				+		+	+	+
Al-Ragged[32]	2007	84	85	15-50	GA	ribbon gauze with Antibiotics, 24h	Vicryl 5-0	3m									+	+	+	+	+
Kazkayasi[33]	2007	18	19	18-54	GA	Merocel with antibiotics, 48h	Chromic cat gut4/0 continuous suture	48h	+					+							
Yildirim[34]	2005	40	40	N/A	LA	finger glove, 48 h	Vicryl 5-0	48h	+												
Nunez(35)	1991	22	21	>18	GA	Vaseline gauze	Dexon 3-0 Quiting suture	6w				+		+				+		+	
Guyuron[36]	1989	23	22	14-61	LA	gauze with polysporin ointment, 24-48 h	Chromic 4-0 quilting sutures	16m									+			+	+
Combination of nasal packing and trans-septal suture versus Trans-septal suture																					
Yadav[37]	2019	30	30	adult	LA	Merocel+TSS, 1d	Vicryl 3-0	10d				+	+		+	+		+	+	+	
Awan[38]	2008	44	44	>15	LA	finger glove+TSS, 1d	Vicryl 2-0	7d			+	+	+		+			+	+	+	
Combination of nasal packing and nasal splint versus Nasal splint																					
Bernado[39]	2013	37	36	16-67	N/A	Ivalon 1d with Shah nasal plate, 7-10d	Shah nasal plate, 7-10d	3mo			+	+	+		+			+	+		
Nasal packing versus Trans-septal suture with nasal splint																					
Caglar[40]	2019	30	30	18-45	N/A	Merocel, unknown duration	Nasal splint	NA					+					+	+		
Naik[41]	2015	90	94	NA mean 31	N/A	antibiotics impregnated gauze, 48h	silicone splint with figure of 8 TSS by Ethilon 3-0, 1 w	12m				+		+					+	+	
Wadhera[42]	2014	30	30	18-50	LA	antibiotics soaked nasal pack	fluoroplastic flexible splint with TSS by Mersilk 3-0	6wk						+	+	+	+	+	+	+	+
Azaka[43]	2012	20	15	20-65	GA	sponge-like packing made from arum root, with antibiotics, 2dd	1mm thick silicone each side fixed by suture, 2w	4wk						+			+			+	
Nasal packing versus Fibrin glue																					
Habesoglu[44]	2010	23	22	18-54	LA	Merocel, 2d	Fibrin glue (Tiseel) 1 mL applied between cartilage and septal flap	14d			+	+						+	+	+	
Nasal packing versus Nasal airway integrated packing																					
Farooq[45]	2016	50	50	16-58	GA	Gauze packing	cut ETT no4-5 or NG tube 16-20FR, with gauze packing	12wk	+		+				+	+		+	+	+	

Table 1 continued.

Authors	Year	Sample size pack	Sample size Oth	Age (years)	TOA	Packing intervention†	Other intervention†	Fol-low up†	RD	O2	SL	P	Inf	Cr	Epi	Dp	Pf	BL	He	Ad	rD
Yilmaz[46]	2013	22	25	adult	LA	Merocel, 2d	silicone intranasal splint with integral airway, 2d	4wk				+	+					+		+	
Yu[47]	2013	39	40	20-54	LA	Nasopore, no removal	nasal airway 5mm integrated Nasopore, 3d	2mo		+		+		+			+	+	+	+	
Acioglu[48]	2012	89	30	17-62	GA	Merocel (30) or finger glove (30) or vasaline gauze (29), 48h	Doyle combo splint, 48h	24h											+		
Zeyyan[49]	2010	20	19	17-47	GA	finger glove packing	tampon with air canals	12h		+											
Yigit[50]	2002	20	20	18-60	N/A	finger glove, at least 2d	finger glove with nasal airway diameter 6mm, length 6-8 cm	2d		+											
Nasal packing versus Nasal retaining devices																					
Fang[51]	2019	17	22	18-64	GA	Merocel, 2d	septal retainer, 2d	3mo			+	+	+		+	+		+	+	+	
Vuluswamy[52]	2012	40	40	>18	LA	finger glove with neosporin ointment, 24h	septal clip (stainless steel clip + polyethelene internal splint)	6wk	+			+			+	+				+	+

Abbreviations: Oth; Other intervention, TOA; Type of anesthesia, RD; Respiratory distress, O2; Oxygen saturation, SL; Sleep disturbance, P; Pain, Inf; Infection, Cr; Crusting, Epi; Epiphora, Dp; Dysphagia, Pf; Perforation, BL;bleeding, He; Hematoma, Ad; Adhesion, rD; Residual of the deviated nasal septum, N/A; Not available, BIPP; Bithmud iodine paraffin paste.
† h=hour, d=day, w=week, m=month.

p < 0.001). The heterogeneity was high (I2 = 94%; p <0.001). The result is shown in Figure 5.

Bleeding
Twenty-eight studies (2,941 participants) were included in this analysis. There was no statistically significant difference between the total nasal packing and other procedures (OR 1.23; 95% CI 0.76–1.99; p= 0.40). The heterogeneity was moderate (I2 = 54%; P< 0.001). The forest plot is shown in the electronic supplement (e-Figure 2).

Hematoma
Thirty-two studies (3,355 participants) were included in this analysis. There was no statistically significant difference between the total nasal packing and other procedures (OR 2.12; 95% CI 0.73–6.12; P = 0.17). The heterogeneity was moderate (I2 = 46%; P = 0.04). The forest plot is shown in the electronic supplement (e-Figure 3).

Sleep disturbance
Seven studies (501 participants) were included in this analysis. The total nasal packing significantly increased the odds of sleep disturbance events compared to other procedures (OR 11.92; 95% CI 4.95–28.66; P < 0.001). The heterogeneity was high (I2 = 71%; P = 0.002). The forest plot is shown in the electronic supplement (e-Figure 4).

Infection
Nineteen studies (1,531 participants) were included in this analysis. There was no statistically significant difference between the total nasal packing and other procedures (OR 2.21; 95% CI 0.84-5.78; P = 0.11). The heterogeneity was low (I2 = 0%; P =0.57). The forest plot is shown in the electronic supplement (e-Figure 5).

Crusting
Eleven studies (947 participants) were included in this analysis. The total nasal packing significantly increased the odds of crusting events compared to other procedures (OR 4.26; 95% CI 1.70-10.69; P = 0.002). The heterogeneity was high (I2 = 70%; P <0.001). The forest plot is shown in the electronic supplement (e-Figure 6).

Table 2. A summary of post-operative complications of the total nasal packing, comparing to other alternatives techniques.

Outcome		Studies	Participants	Statistical methods	Effect	95%CI	p-value	I2 (p-value)
1	Respiratory distress	6	596	OR (RE)	18.18	8.21, 40.27	<0.001	49% (0.008)
2	Oxygen saturation	6	319	MD (RE)	-2.01	-4.03, 0.01	0.05	98% (<0.001)
3	pain severity	21	1,488	SMD (RE)	1.79	1.31, 2.28	<0.001	94% (<0.001)
4	Bleeding	28	2,941	OR (RE)	1.23	0.76, 1.99	0.40	54% (0.001)
5	Hematoma	32	3,355	OR (RE)	2.12	0.73, 6.12	0.17	46% (0.04)
6	Sleep disturbance	7	501	OR (RE)	11.92	4.95, 28.66	<0.001	71% (0.002)
7	Infection	19	1,513	OR (FE)	2.21	0.84, 5.78	0.11	0% (0.57)
8	Crusting	11	937	OR (RE)	4.26	1.70, 10.69	0.002	70% (<0.001)
9	Epiphora	9	657	OR (RE)	65.91	12.87, 337.42	<0.001	81% (<0.001)
10	Dysphagia	6	452	OR (RE)	59.78	5.52, 647.53	<0.001	91% (<0.001)
11	Perforation	21	2,394	OR (FE)	1.67	0.87, 3.19	0.12	0% (0.99)
12	Adhesion	32	3,003	OR (FE)	2.40	1.64, 3.51	<0.001	0% (0.65)
13	residual DNS	13	1,118	OR (FE)	0.93	0.59, 1.49	0.78	26% (0.22)

OR; Odd ratio, MD; Mean difference, SMD; Standardized mean difference, RE; Random effect model, FE; Fixed effect model DNS; deviation of nasal septum.

Table 3. A summary of respiratory distress definition among the included studies.

Study (author, year, reference number)	Respiratory distress definition
Gunaydin 2011[25]	Extubation difficulty score > 1. Extubation was scored, based on the amount of secretion, the occurrence of laryngospasm, the need for oropharyngeal airway usage, and the effort of nasal breathing by an anesthesiologist. The score was in 0-4 scale: 0 easiest, 1 easy, 2 moderately difficult, 3 difficult, 4 most difficult.
Cayonu 2014[17]	Respiratory events related to anesthesia in the operating theatre, defined as any unanticipated • hypoxemia (hemoglobin oxygen saturation <90%) • hypoventilation (respiratory rate <8 breaths/min or arterial carbon dioxide tension >50 mmHg) • upper airway obstruction (stridor or laryngospasm) requiring an active and specific intervention (ventilation, tracheal intubation, opioid or muscle relaxant antagonism, insertion of oral/nasal airway or airway manipulation)
Ozbalkoc 2016[54]	Anesthesia related parameters: Difficulty at extubation. Of note, this study also recorded other anesthesia related parameters which were not included in the forest plot (presence of laryngospasm after surgery, need for oropharyngeal airway, effort for nasal respiration)
Dadgarnia 2017[11]	Presence of dyspnea symptoms in the first 48 hours after surgery, complaint by the patient
Faroog 2016[45]	Presence of difficult recovery from general anesthesia, including unsmooth or late recovery considered by doctors
Vulsvamy 2012[52]	Average oxygen saturation <95% from the 6-hour record of post-operative continuous oxygen saturation (SpO2) monitoring, every 30 minutes.

Epiphora

Nine studies (657 participants) were included in this analysis. The total nasal packing significantly increased the odds of epiphora events compared to other procedures (OR 65.91; 95% CI 12.87-337.42; P <0.001). The heterogeneity was high (I2 = 81%; P <0.001). The forest plot is shown in the electronic supplement (e-Figure 7).

Dysphagia

Six studies (452 participants) were included in this analysis. The total nasal packing significantly increased the odds of dysphagia events compared to other procedures (OR 59.78; 95% CI 5.52-647.53; P <0.001). The heterogeneity was high (I2 = 91%; P <0.001). The forest plot is shown in the electronic supplement (e-Figure 8).

Perforation

Twenty-one studies (2,394 participants) were included in this analysis. There was no statistically significant difference between the total nasal packing and other procedures (OR 1.67; 95% CI 0.87-3.19; P = 0.12). The heterogeneity was low (I2 = 0%; P = 0.99). The forest plot is shown in the electronic supplement

(e-Figure 9).

Adhesion
Thirty-two studies (3,003 participants) were included in this analysis. The total nasal packing significantly increased the odds of adhesion events compared to other procedures (OR 2.40; 95% CI 1.64–3.51; P <0.001). The heterogeneity was low (I2 = 0%; P = 0.65). The result is shown in Figure 6.

Residual deviation of the nasal septum
Thirty studies (1,118 participants) were included in this analysis There was no statistically significant difference between the total nasal packing and other procedures (OR 0.93; 95% CI 0.59–1.49; P = 0.78). The heterogeneity was low (I2 = 26%; P = 0.22) The forest plot is shown in the electronic supplement (e-Figure 10).

Subgroup analysis by the techniques
Total nasal packing versus trans-septal suture
There were 30 studies comparing postoperative complications between total nasal packing and trans-septal suture. The results favored the trans-septal suture over the nasal packing, for decreasing respiratory distress, pain, sleep disturbance, crusting, epiphora, dysphagia, and adhesion. There were no significant differences in oxygen saturation, bleeding, hematoma, infection, perforation, and residual deviation of the nasal septum. A summary of postoperative complications between nasal packing and trans-septal suture is presented in the electronic supplement (e-Table 1).

Combination of nasal packing and trans-septal suture versus trans-septal suture alone
There were 3 studies comparing the nasal packing and trans-septal suture combination versus trans-septal suture alone. The sleep disturbance, epiphora, and dysphagia were significantly higher in the combination technique. There were no significant differences in pain severity, infection, bleeding, and hematoma. Other outcomes could not be analyzed due to insufficient number of studies.

Total nasal packing versus trans-septal suture with nasal splint
There were 5 studies comparing total nasal packing versus trans-septal suture with splint. The crusting was worsened in the total nasal packing. There were no significant differences in pain severity, bleeding, hematoma, perforation, and adhesion. Other outcomes could not be analyzed due to insufficient number of studies.

Total nasal packing versus nasal airway integrated packing
There were 8 studies comparing total nasal packing versus nasal airway integrated packing. However, there was only 1 study for each of the following outcomes that statistically favored the nasal airway integrated packing: respiratory distress, sleep disturbance, and epiphora. There were no statistical differences in oxygen saturation, pain severity, infection, dysphagia, perforation, bleeding, hematoma, and adhesion. None of the studies compared the residual deviated nasal septum.

Combination of nasal packing and nasal splint, nasal retaining devices, and fibrin glue
There was an insufficient number of the studies for each analysis.

Sensitivity analysis
We performed a sensitivity analysis based on methodological characteristics. The analysis of high-quality studies showed a consistency of results in most of the outcomes. The number of high-quality studies in crusting were too few to perform a sensitivity analysis. Some outcomes of the meta-analysis had significant heterogeneities. Therefore, a sensitivity analysis of these outcomes was performed by excluding the studies that contributed the most to the I2. The sensitivity analyses after excluding the outliers showed consistent results.
Different types of pain score were used among the studies to assess the pain severity outcome. The most frequently used was visual analog scale (VAS), the score ranged from 0 to 10. The sensitivity analysis was performed in the studies that used the VAS 0–10. We found that the mean difference of VAS in nasal packing group was higher than other techniques by 3 points. Results are shown in the electronic supplement (e-Figure 11).

Publication bias
The funnel plots of most outcomes revealed that the distribution of the studies was reasonably symmetrical which suggested no evidence of publication bias. However, the funnel plots of epiphora and dysphagia events revealed asymmetrical distribution which suggested the publication bias. The funnel plots are shown in the electronic supplement (e-Figure 12).

Discussion
The results of this meta-analysis demonstrated that nasal packing after septoplasty was more likely to cause adverse events, including respiratory distress, pain, sleep disturbance, crusting, epiphora, dysphagia, and adhesion. Nasal packing did not show benefits in preventing bleeding, hematoma, and residual nasal septum deviation when compared with other techniques. Subgroup analyses results favored the trans-septal suture over the nasal packing, for decreasing respiratory distress, pain, sleep disturbance, crusting, epiphora, dysphagia, and adhesion. There were no significant differences in oxygen desaturation, infection, septal perforation, bleeding, hematoma, and residual nasal septum deviation. Adding nasal packing to trans-septal suture

increased sleep disturbance, epiphora, and dysphagia but did not decrease bleeding and hematoma. Trans-septal suture with splint had benefit over nasal packing only in decreasing the crust but no significant differences in other outcomes. There were insufficient randomized control studies of other techniques, including the nasal airway integrated packing, nasal retaining devices, and fibrin glue, for the subgroup analyses. In-line with the previous meta-analyses[4-7], the results of this study did not find any significant differences between the nasal packing and trans-septal suture in bleeding, hematoma, perforation, and residual septal deviation. Our study also found that the trans-septal suture had a significant advantage over the nasal packing in decreasing post-operative pain. The analysis of adhesion outcome is consistent with the previous meta-analyses by Kim et al. and Wang et al.[6,7], which concluded that the nasal packing had a higher adhesion rate than trans-septal suture. However, the other meta-analyses by Banglawala (2013) et al. and Certal et al.[4,5] did not find a significant difference in adhesion rate. There was no difference in infection rate which is consistent with the previous meta-analyses[5-7]. A meta-analysis performed by Banglawala (2014) et al.[8] did not find significant oxygen desaturation caused by nasal packing, which is consistent with our study. However, we found that nasal packing caused respiratory distress which is more important than desaturation due to the possibility of causing serious consequences.

The safety of nasal packing after septoplasty should be strongly considered because this meta-analysis showed both statistically and clinically significant increases in adverse events (respiratory distress, sleep disturbance, crusting, epiphora, dysphagia, and adhesion) when compare to other techniques. In addition, the sensitivity analysis of pain score showed an increase in VAS by 3 out of the 10-point pain score. Furthermore, it did not have advantages over other techniques in the prevention of bleeding, hematoma, and residual septal deviation. As for clinical implications, this meta-analysis suggested that routine nasal packing after septoplasty should be avoided since it could cause adverse events, especially respiratory distress. The technique with sufficient evidence that can be used as an alternative to the nasal packing is trans-septal suture. Future research with well-designed RCTs, comparing other techniques to the trans-septal suture should be performed.

This is the first meta-analysis that assessed respiratory distress, sleep disturbance, crusting, epiphora, and dysphagia in addition to other outcomes. The alternative techniques other than trans-septal suture were also included in this meta-analysis. Moreover, our analysis also included the primary studies that were not published in English. The limitations of our study included the measurements of the primary outcome that were different among the studies; for example, the definition of respiratory distress event was different in each included study and most of them were subjective outcomes reported by either anesthesiologists or patients. Nevertheless, we thought that those events could be pooled as the respiratory distress event, because they were all unwanted adverse outcomes that could cause serious consequences. The low quality of the included studies was another limitation, such as the studies with no explanations about the randomization and allocation concealment. Most of the included studies had high risk of performance bias. The post-operative procedure could not be blinded; therefore, we had to be cautious since it could influence the subjective outcomes. In addition, the funnel plots showed publication bias in epiphora and dysphagia. The high heterogeneity of the included studies was due to the data being pooled from studies with different surgical techniques, anesthetic techniques and outcome measurement tools. We accepted the inherent heterogeneity and used a random-effects model for analysis and performed a sensitivity analysis by excluding the outliers that caused the most heterogeneity. The sensitivity analysis showed a consistency of results. Further well-designed research should be performed regarding these limitations.

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Authorship contribution

CKT, PH: designed the concept. CKT, NC, BC: performed data searching, study selection, quality assessment. PH: resolved the discrepancies. CKT, NC: extracted data. CKT: analyzed data. CKT, PH: interpreted data. CKT, drafted the article. NC, BC, PH: provided the feedback, revised the article. CKT: wrote manuscript, sent for English language editing. CKT, PH: approved the final version of manuscript.

Conflict of interest

None.

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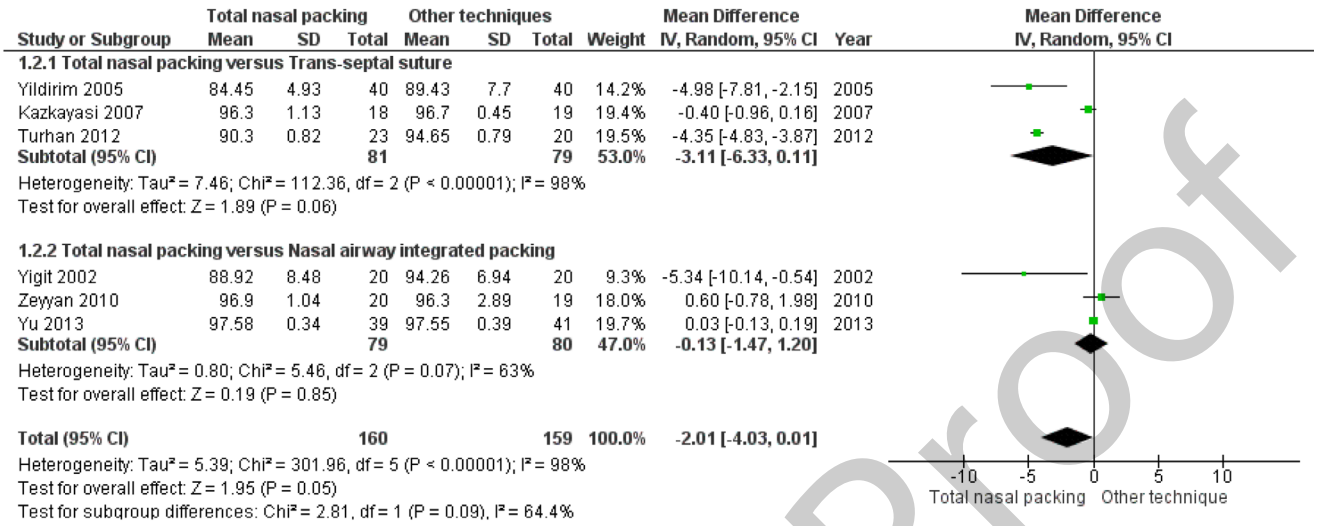
Chernkwan K. Titirungruang, MD
Department of Otolaryngology
Faculty of Medicine
Chulalongkorn University
1873, Rama 4 rd.
Bangkok, 10330
Thailand

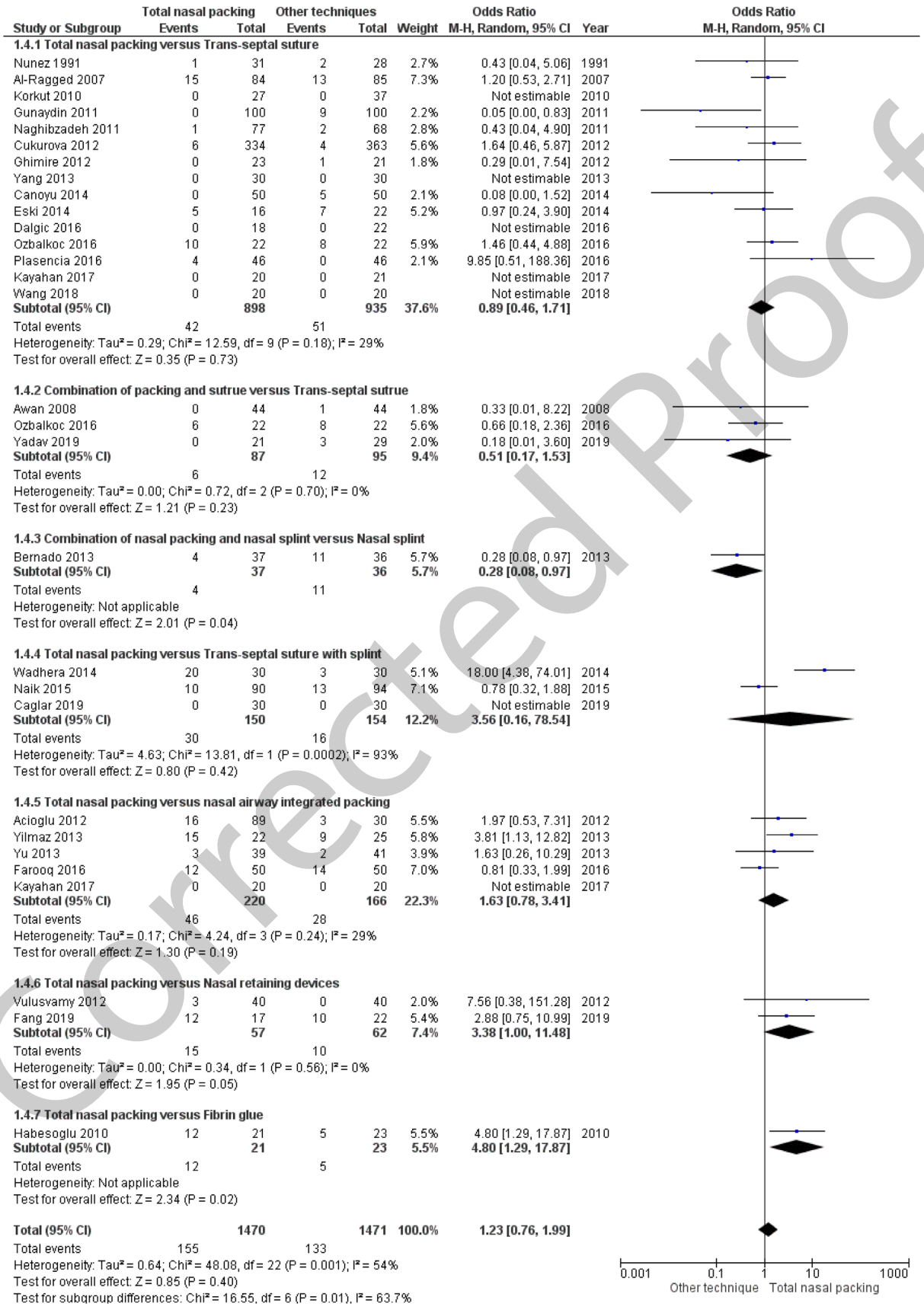
E-mail: c.titirungruang@gmail.com

This manuscript contains online supplementary material

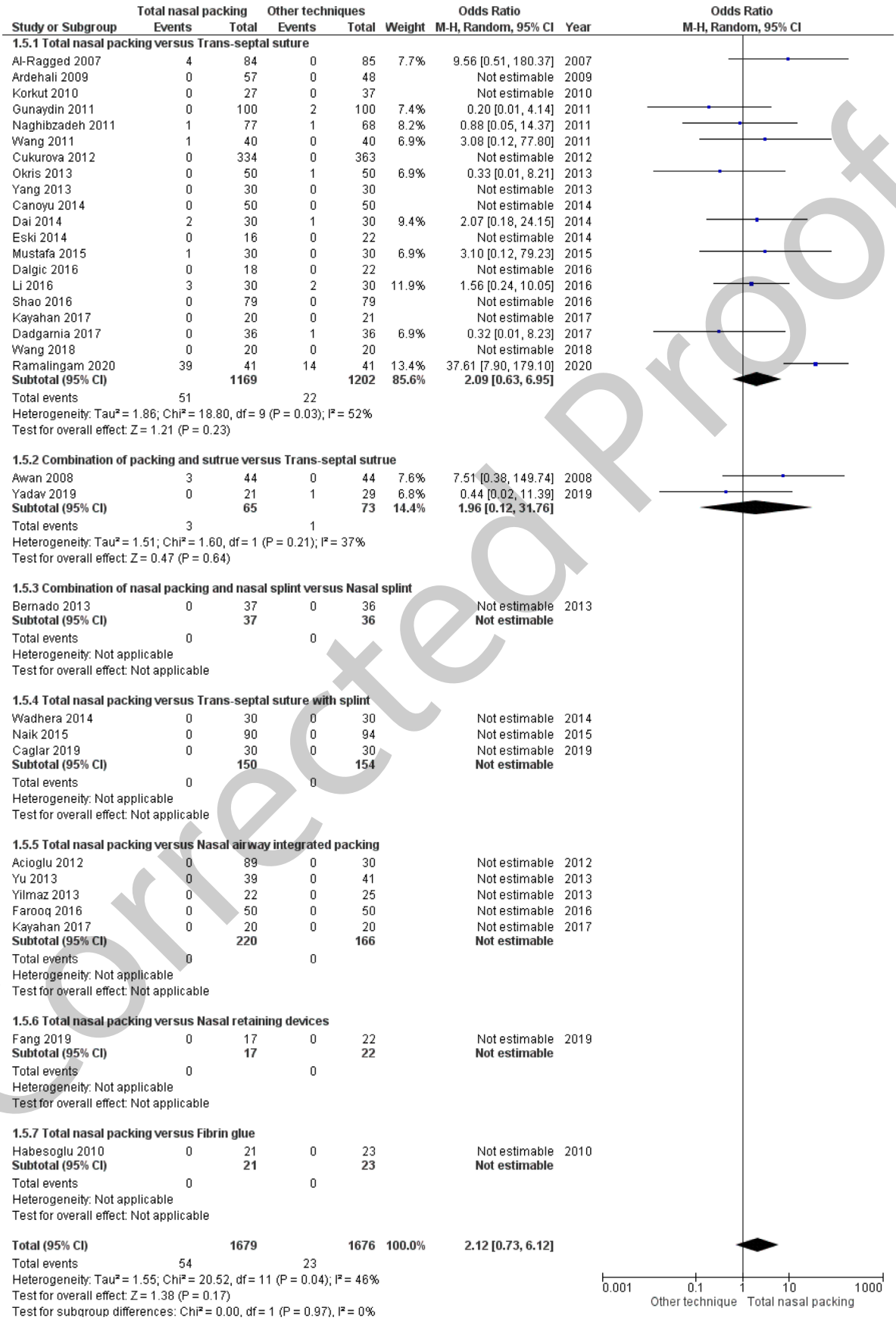
E-figure 1. Oxygen saturation, mean difference (MD), Total nasal packing versus other techniques: random-effect model.



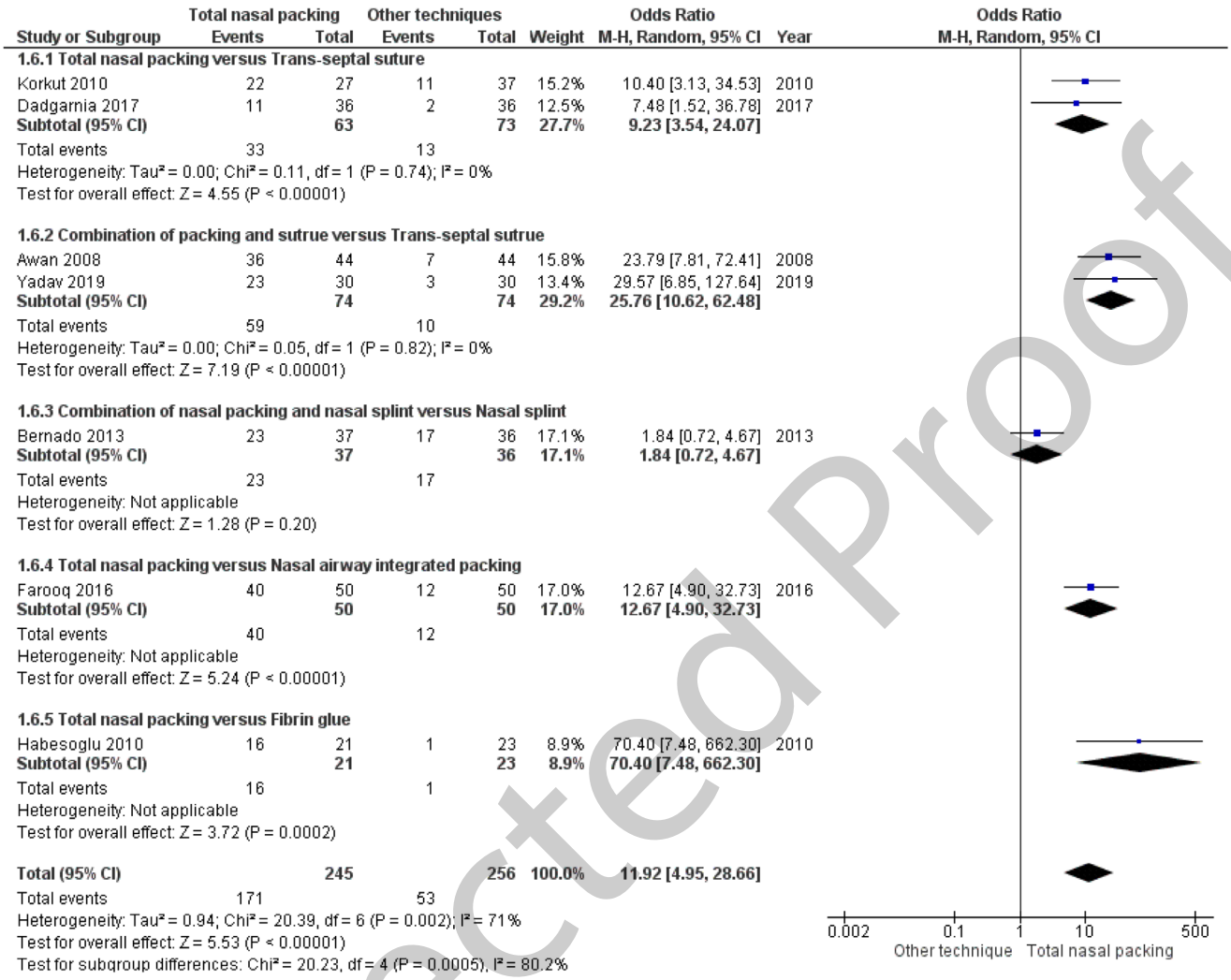
E-figure 2. Bleeding, odds ratio (OR), Total nasal packing versus other techniques: random-effect model.



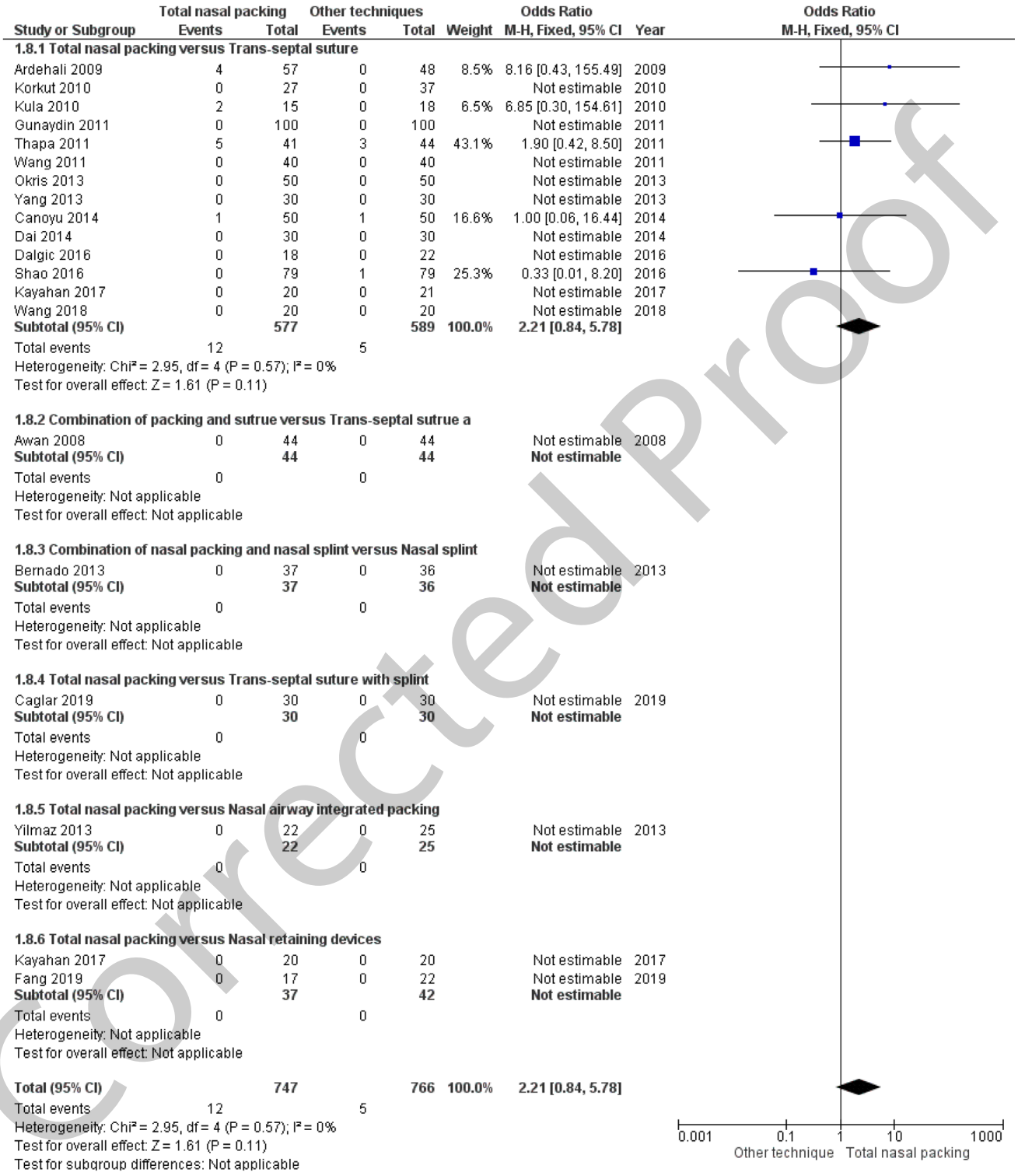
E-figure 3. Hematoma, odds ratio (OR), Total nasal packing versus other techniques: random-effect model.



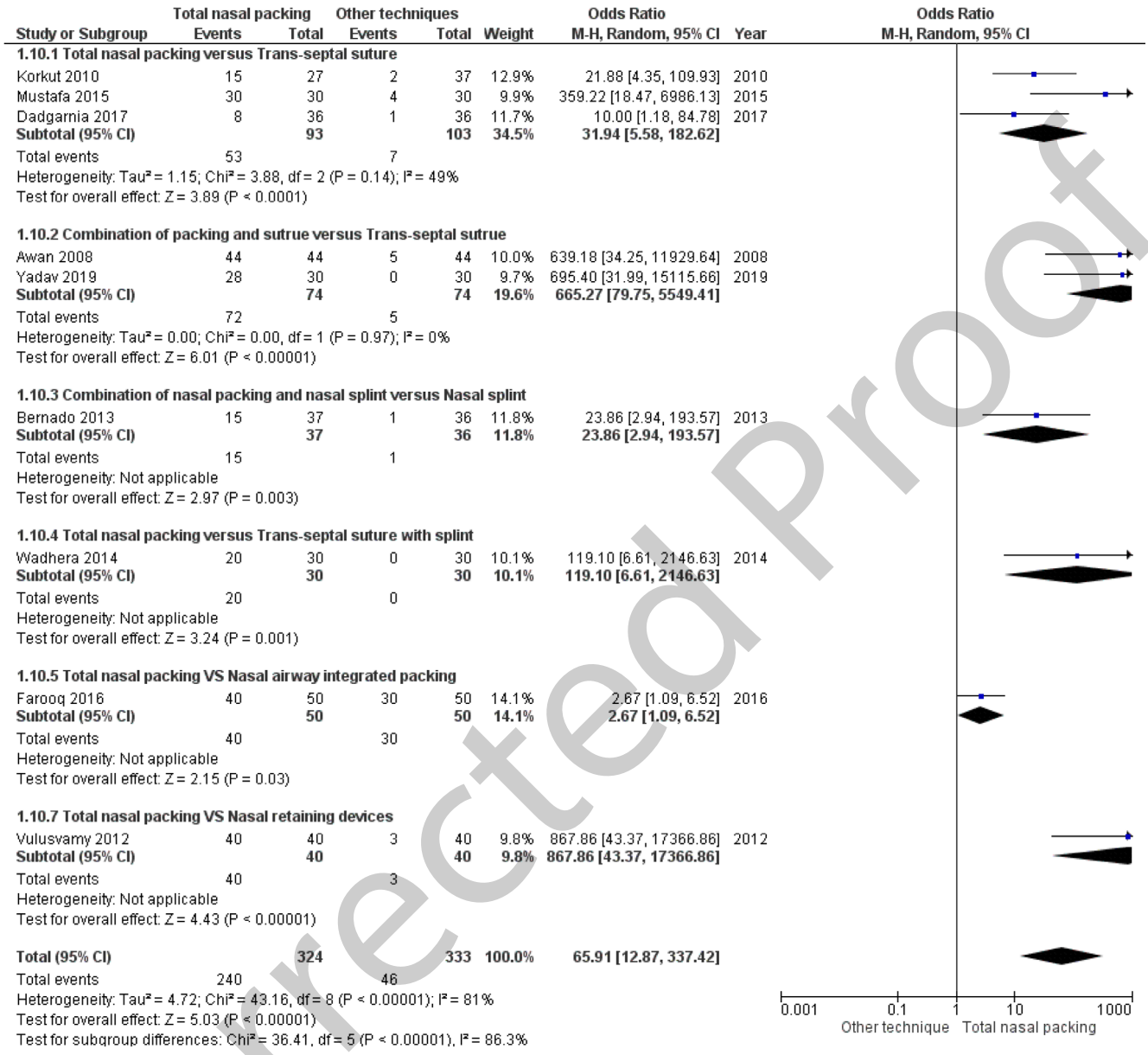
E-figure 4. Sleep disturbance, odds ratio (OR), Total nasal packing versus other techniques: random-effect model.



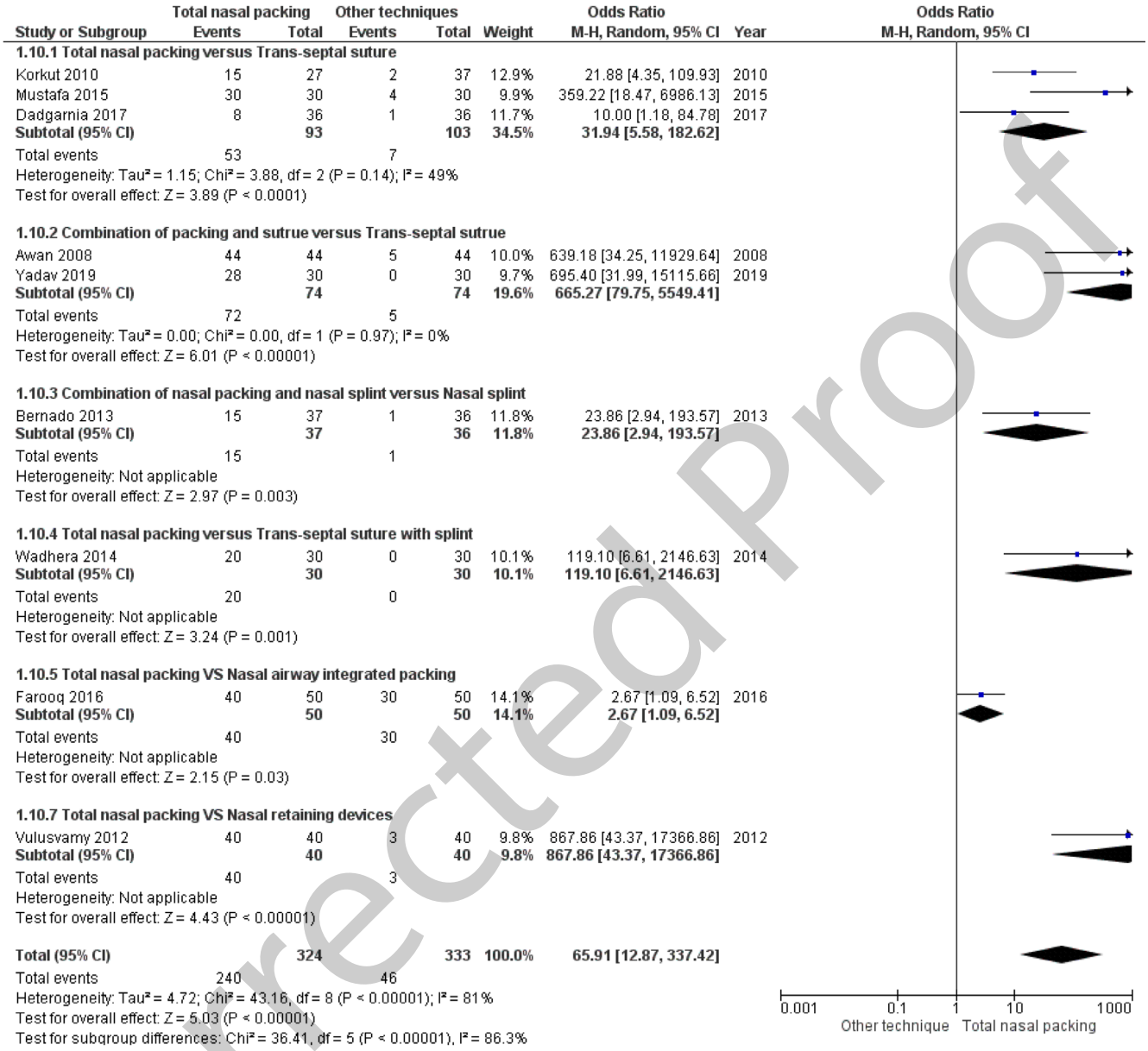
E-figure 5. Infection, odds ratio (OR), Total nasal packing versus other techniques: fixed-effect model.



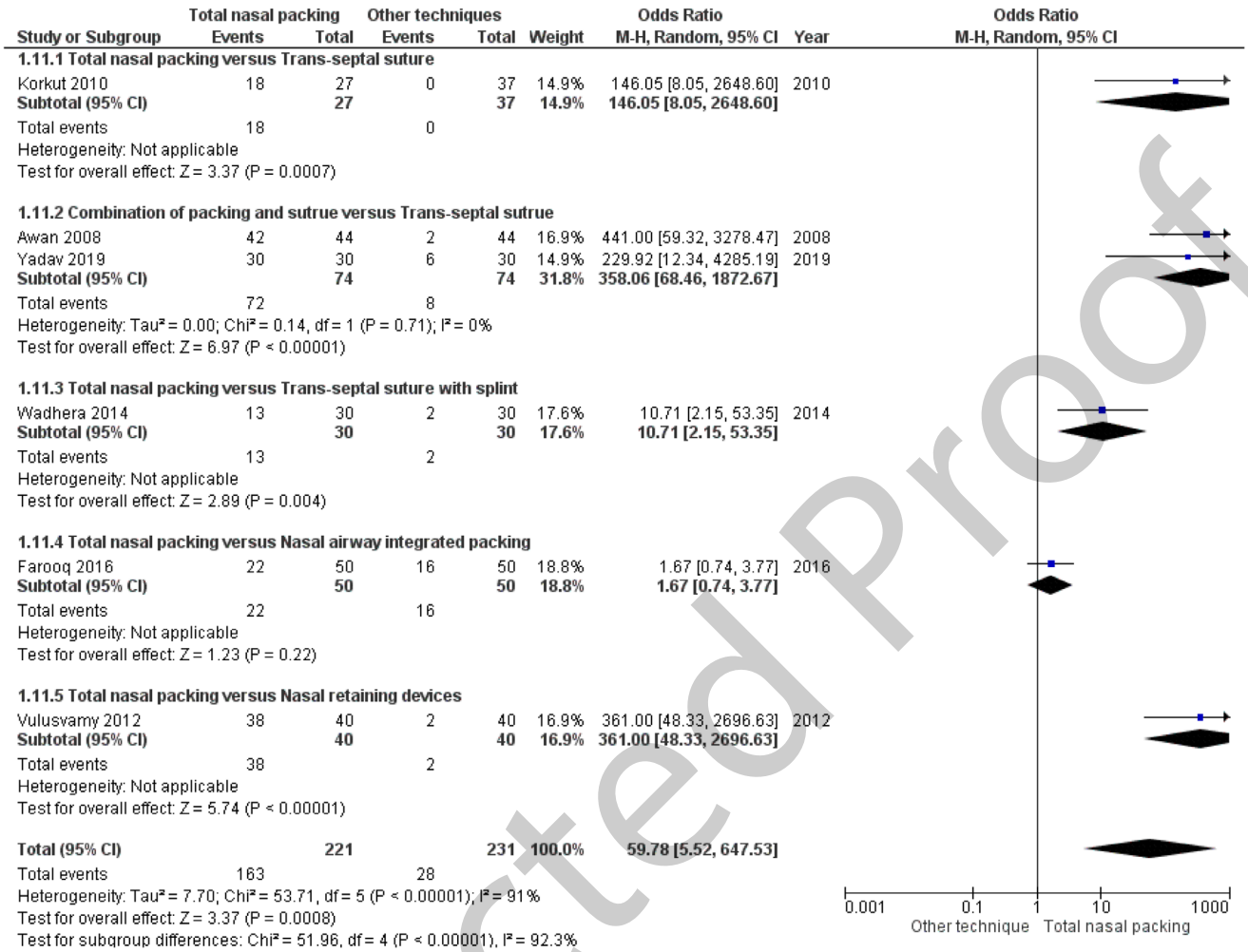
E-figure 6. Crusting, odds ratio (OR), Total nasal packing versus other techniques: random-effect model.



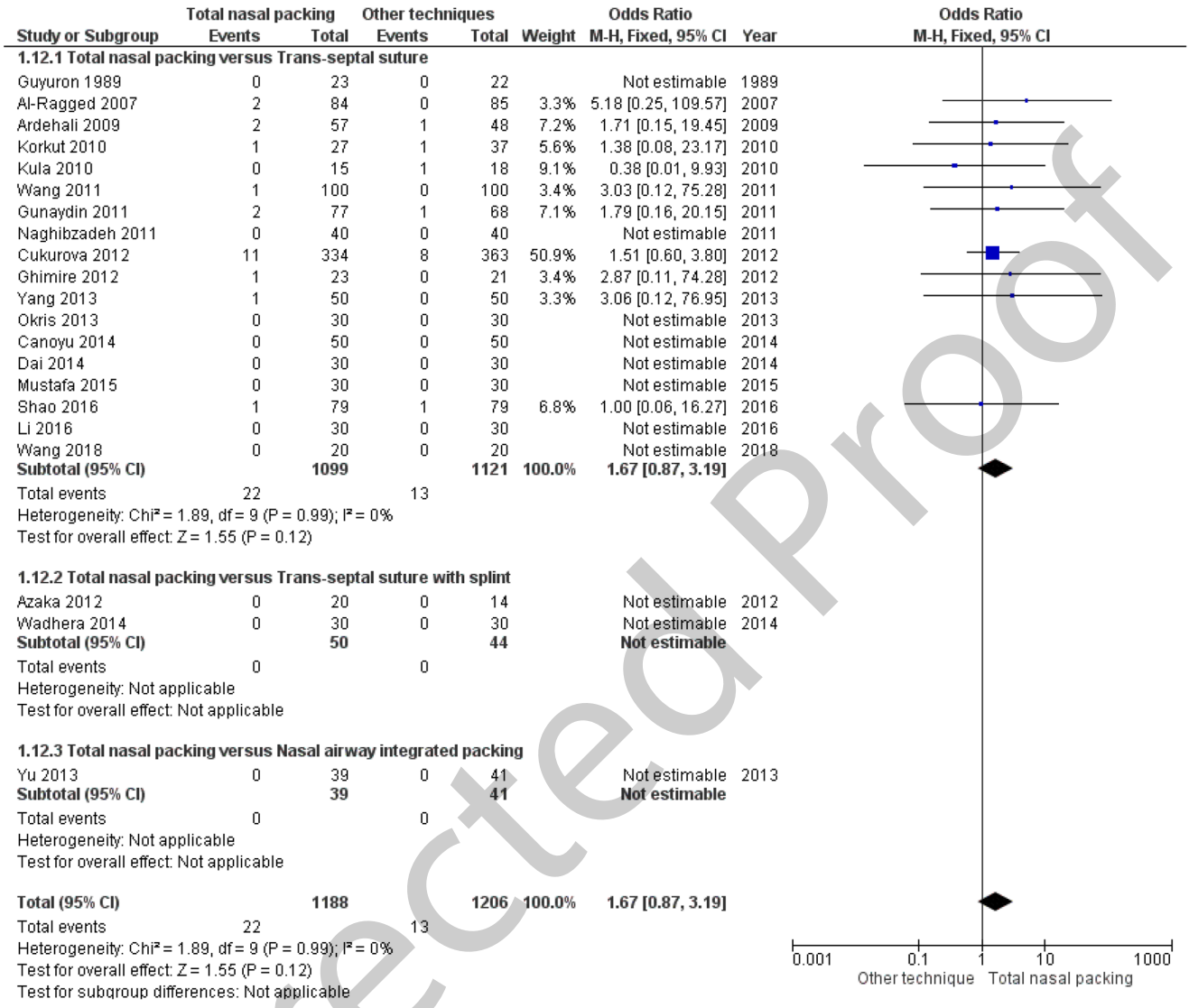
E-figure 7. Epiphora, odds ratio (OR), Total nasal packing versus other techniques: random-effect model.



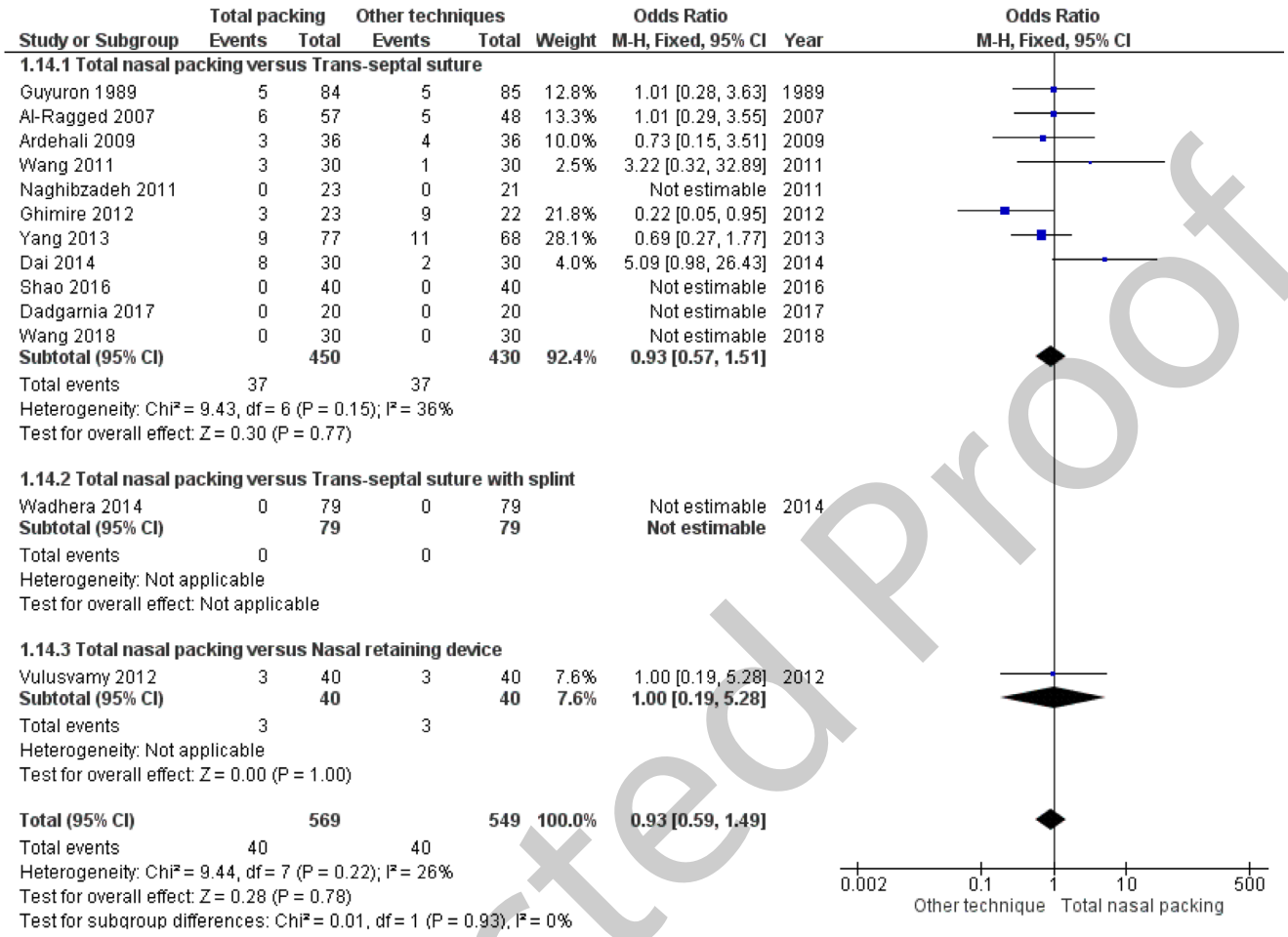
E-figure 8. Dysphagia, odds ratio (OR), Total nasal packing versus other techniques: random-effect model.



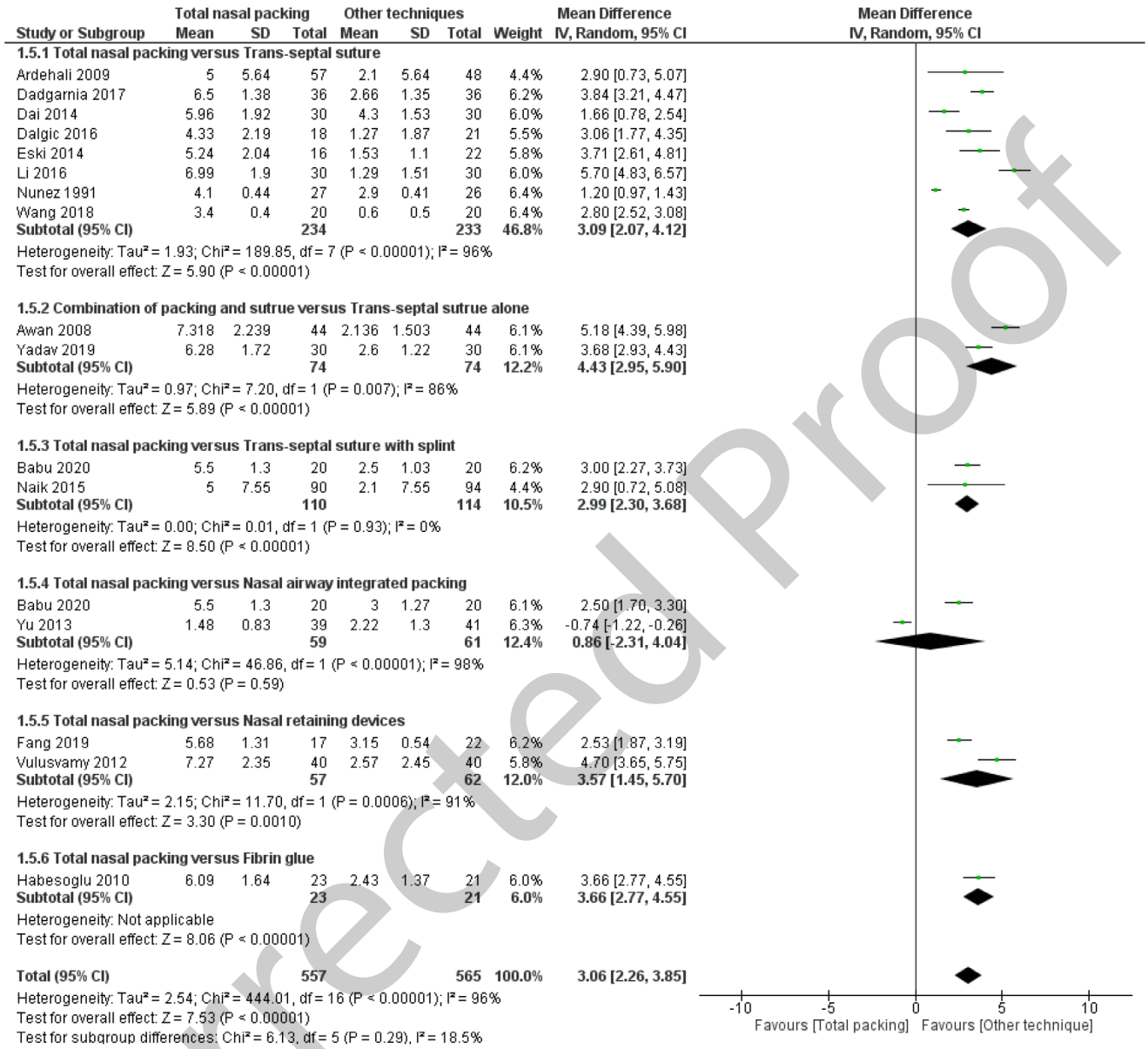
E-figure 9. Perforation, odds ratio (OR), Total nasal packing versus other techniques: fixed-effect model.



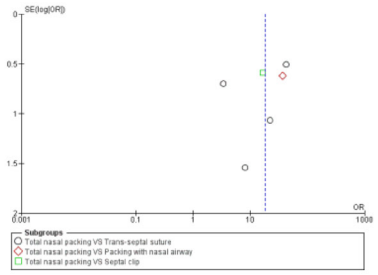
E-figure 10. Residual septal deviation, odds ratio (OR), Total nasal packing versus other techniques: fixed-effect model.



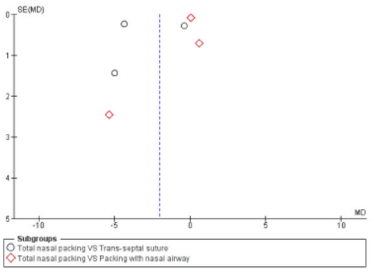
E-figure 11. Pain severity VAS 0-10, mean difference (MD) Total nasal packing versus other techniques: random-effect model.



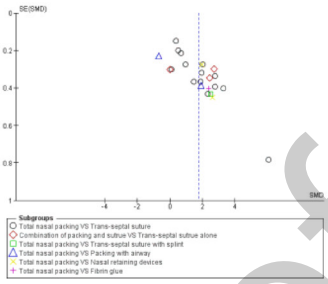
E-figure 12. Funnel plots: all outcomes.



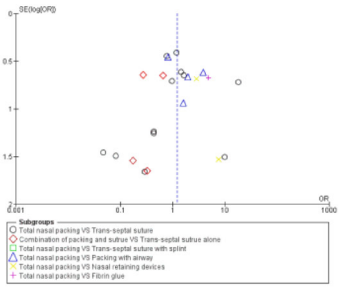
respiratory distress



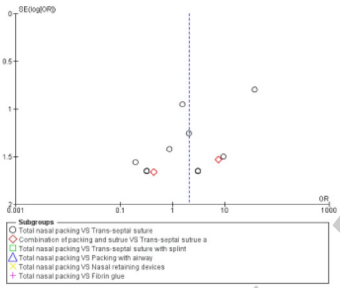
oxygen saturation



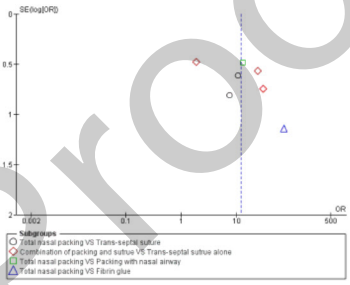
pain



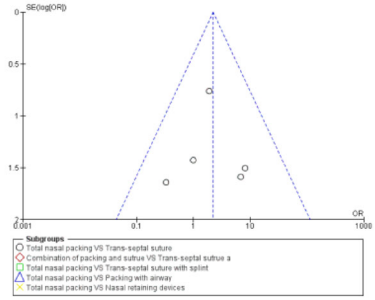
Bleeding



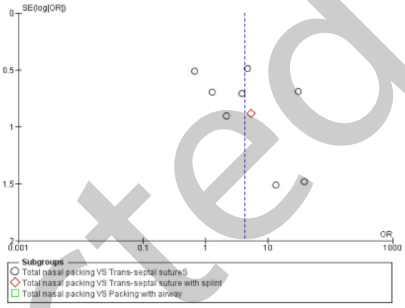
Hematoma



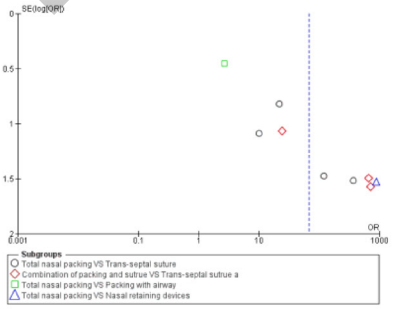
Sleep disturbance



Infection

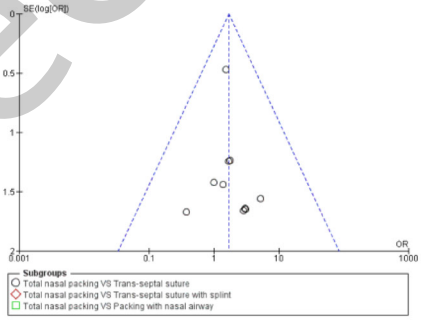


Crusting

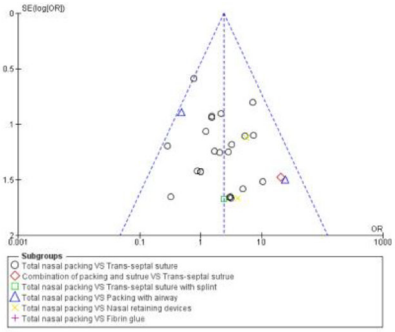


Epiphora

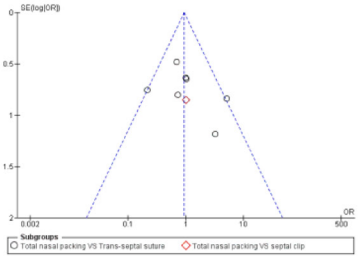
Dysphagia



Perforation



Adhesion



Residual septal deviation