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1 **Peri-operative management of endoscopic endonasal cerebrospinal fluid leak repair: an**
2 **international survey**

3

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36

37 **Abstract**

38

39 Objective: To examine practice patterns of peri-operative management practice in
40 cerebrospinal fluid (CSF) leak closure in endoscopic endonasal skull base surgery among skull
41 base surgeons to identify area of consensus making it possible to standardize practices.

42 Study design: 60-items survey questionnaire

43 Setting: Members of international learned societies of ENT surgeons and neurosurgeons

44 Methods: The questionnaire gathered the opinion on nasal packing, post-operative
45 instructions, limitation of activities, antibiotic prophylaxis and CSF volume depletion.

46 Results: 153 surgeons (124 otorhinolaryngologists and 29 neurosurgeons) answered the
47 survey. A resting position was recommended by 85% (130/151) of respondents for extended
48 CSF leak and located in the anterior skull base, by 83% (127/149) of respondents for CSF leak
49 of the *planum sphenoidale* and 79.1% (121/143) for CSF leaks of the clivus. Fowler's position
50 was favoured by 72% (110/153) of respondents independently to the size and location of the
51 CSF leak. The duration of the resting position was 24-48 hours for 70% of respondents in
52 case of small CSF leaks of the anterior skull base and sphenoid. For extended CSF leaks of the
53 anterior skull base, sphenoid or clivus, the duration was longer than 48 hours for $\geq 55\%$ of
54 respondents. ENT surgeons recommended more often a resting position than neurosurgeons
55 ($p=0.0008$) and prescribed more antibiotics ($p<0.0001$).

56 Conclusion: Although postoperative management after CSF closure remains challenging and
57 not codified, this international survey revealed some points of consensus concerning resting
58 position and restriction of post-operative activities. Prospective clinical studies must be
59 achieved to evaluate their efficiency.

60

- 61 **Keywords:** skull base, intracranial pressure, CSF leak, endoscopic skull base surgery, CSF
- 62 depletion, acetazolamide

63 **Introduction**

64 The prevalence of nasal cerebrospinal fluid (CSF) leak is low in the general population
65 [1] but it can be light-threatening, mainly due to the risk of meningitis [2]. It may occur after
66 head trauma, surgery, tumor resection, or congenital malformation. In rare cases, CSF leak is
67 spontaneous and should be considered associated with idiopathic intracranial hypertension
68 [3]. Endoscopic endonasal skull base surgery (EESBS) has become the gold-standard for the
69 surgical management of nasal CSF leaks, restoring the barrier between the subdural space
70 and sinonasal cavities. Achieving a watertight surgical closure of CSF leaks remains a
71 challenge and many techniques have been described, using autologous free grafts (fascia
72 lata, abdominal fat, cartilage, turbinate) [4–6], heterologous material (Tachosil® sealant) [7],
73 local and regional pedicled flaps [8–10] or free flaps [11]. As frequently when there is
74 multiple techniques described, it is because none is better than the other. Nevertheless,
75 multilayer reconstruction allowed overall success of about 95% with a low morbidity [6,12].

76 However, the results of reconstruction and the absence of complications are
77 multifactorial and depends on the surgical techniques used in ESSBS but also on the
78 perioperative care: rest position, anticoagulation, antibiotic therapy, and/or patient activity
79 restrictions. Some studies have analyzed the risk factors for failure of skull base
80 reconstructions, in which the management of intracranial pressure (ICP) being a key element
81 in the success of surgery [13]. Post-operative antibiotic therapy is debated but may not be
82 necessary because of the risk of masking nosocomial meningitis [14]. Prospective studies are
83 rare and there is no expert consensus regarding the perioperative measures to be
84 implemented after CSF leak closure [15].

85 The main aim of this study was to identify key factors of the peri-operative
86 management of endoscopic endonasal CSF leak repair.

87 **Material and methods**

88 A 60-items survey questionnaire divided in 6 sections was conducted.

89 Questionnaire elaboration and diffusion

90 The questionnaire was developed by the French Association of Rhinology board and made
91 available in French, Italian and English languages. It questioned the experts on their use of
92 nasal packing, postoperative instructions, use of antibiotic prophylaxis or CSF volume
93 depletion, the limitation of activities recommended to patients. The survey was sent to the
94 members of international learned skull base societies (French Association of Rhinology,
95 French College of Neurosurgeons, Italian Skull Base Society, and European Rhinologic
96 Society). Data were collected from January 2019 through September 2019. In order to
97 prevent multiple participations and to be able to communicate the results of this survey,
98 respondents were identified by an email address.

99 Ethical consideration

100 Consent was obtained by participants and data was anonymized. This study was approved by
101 the institutional review board of the Montpellier University Hospital, Montpellier, France
102 (2019_IRM-MTP_10-12) and was registered on clinicaltrial.gov (RECHMPL19_0468).

103 Statistics

104 The values presented correspond to the numbers (proportions) for the categorical variables
105 and to the means (\pm standard deviation) for the quantitative variables. A comparative
106 analysis was carried out using the following tests: for categorical variables (comparison of
107 proportions between several samples) a parametric Chi2 test when possible or failing that a
108 Fisher exact test when the assumptions of normality of the residuals were not respected; for
109 continuous variables, the non-parametric Mann–Whitney U test Kruskal–Wallis test was
110 used (generalization of the Mann–Whitney U test for comparisons of more than 3 groups),

111 because the normality of the distribution was not respected. Statistical analyses were
112 performed using R version 4.1.2 (R Foundation for Statistical Computing, Vienna, Austria).
113 The significance threshold for the p-value was set at 0.05.

114

115 **Results**

116 Demographic data

117 153 skull base surgeons (124 ENT and 29 neurosurgeons), responded to the survey. They
118 practiced in University Hospitals in 76.5% of cases (117/153). The ENT and neurosurgery
119 teams were in the same building in 58.2% of cases (89/153) and worked collaboratively for
120 the management of CSF leak in 86.9% of cases (133/153). Forty percent of participants
121 (63/153) had more than 10 years of experience in EESBS. Demographic data are summarized
122 in **Table 1**.

123 Nasal packing

124 A nasal packing was used by 85% (130/153) of respondents, in all cases for 35.9% (55/153) of
125 respondents. The nasal packing was used to stabilize the reconstruction for 33.3% (51/153)
126 and to prevent bleeding for 22.2% (34/153) of respondents. It was usually removed after 48
127 hours in 44.4% of cases (68/153) and rarely after more than 72 hours (4.6%; 7/153).

128 Postoperative resting position

129 A resting position was recommended by 85% (130/151) of respondents for extended CSF
130 leak of the anterior skull base, by 83% (127/149) of respondents for CSF leak of the *planum*
131 *sphenoidale* and 79.1% (121/143) for CSF leaks of the clivus. Fowler's position was favored
132 by 72% (110/153) of respondents independently to the size and location of the CSF leak. The
133 supine position was used by 21% (32/153) of respondents for small CSF leaks of the anterior
134 skull base and CSF leaks of the sphenoid, and by 27% (41/153) of respondent for extended

135 CSF leaks of the anterior skull base and CSF leaks of the clivus. The duration of the resting
136 position was 24-48 hours for 70% (107/153) of respondents in case of small CSF leaks of the
137 anterior skull base and sphenoid. For extended CSF leaks of the anterior skull base, sphenoid
138 or clivus, the duration was longer than 48 hours for 55.4%, 57.5% and 57% of the
139 respondents respectively.

140 Postoperative medication

141 Thromboprophylaxis was prescribed by 81.7% (125/153) of respondents. For 71.2% (89/125)
142 of them the duration paralleled the bed rest period. A laxative therapy was used by 88.2%
143 (135/153) of respondents: systematically for 38.5% (52/135) of them and only in case of
144 constipation for 55.6% (75/135). The duration was of 5 days or less for 63.7% (86/135).
145 Acetazolamide was prescribed to reduce the ICP by 56.2% (86/153) of respondents. It was
146 prescribed in all cases for 20.9% (18/86), in case of increased ICP for 65.1% (56/86), in case
147 of extended CSF leaks for 20.9% (18/86) and in case of postoperative leak for 23.3% (20/86).
148 Mannitol was used by 28.8% (44/153) of respondents when ICP was increased, and loop
149 diuretics were used by 15.7% (24/153) of respondents. A pneumococcal vaccine was
150 recommended by 57.5% (88/153) of respondents. Antibiotic prophylaxis was prescribed by
151 74.5% (114/153) of respondents and consisted in amoxicillin + clavulanic acid for 43.9%
152 (50/114), cefazolin for 34.2% (29/114) and ceftriaxone for 8.8% (10/114). The duration of
153 antibiotic prophylaxis was less than 3 days for 18.4% (21/114) of respondents, 3 to 5 days for
154 28.9% (33/114), more than 5 days for 42.1% (48/114) and for the duration of nasal packing
155 for 9.6% (11/114) of respondents.

156 Perioperative CSF depletion

157 A CSF depletion was considered by 74.5% (114/153) of respondents. It was done by 47.1%
158 (72/153) of respondents if the patient has a recurrence of the leak; by 34.6% (53/153) in

159 case of increased ICP, by 19.6% (30/153) for extended CSF leak of the anterior skull base, by
160 16.3% (25/153) for extended CSF leaks of the sphenoid, and by 12.4% (19/153) for leaks of
161 the clivus. CSF depletion was performed by 5.9% (9/153) of respondents only before the
162 surgical procedure, by 38.6% (59/153) before and after the surgical procedure, and 30.1%
163 (46/153) only after the surgery. A single lumbar puncture, multiple lumbar punctures and
164 lumbar drain were used by 25% (17/68), 8.8% (6/68) and 63.2% (43/68) of respondents
165 respectively in the preoperative period, and by 12.3% (13/106), 14.2% (15/106) and 74.5%
166 (79/106) of respondents respectively in the postoperative period. Only 9.7% (12/124) of ENT
167 surgeons performed a CSF depletion themselves.

168 Postoperative instructions

169 All respondents gave specific postoperative instructions to their patients particularly in the
170 delay in use of the Continuous Positive Airway Pressure device (CPAP) (**Table 2**). A
171 postoperative in-office debridement was performed by 62.1% (95/153) of respondents (71%
172 (88/124) of ENTs and 24.1% (7/29) of neurosurgeons, $p < 0.001$). Advice on postoperative
173 activities were summarized in **Table 3** and a consensus tended to appear for running,
174 swimming, diving, and bodybuilding restrictions.

175 Subgroup analysis

176 A comparison of management for the mean results regarding the surgical specialty (**Table 4**),
177 experience (**Table 5**) and type of practice (**Table 6**) was also performed. ENT surgeons
178 recommended more often a resting position than neurosurgeons ($p = 0.0008$) and prescribed
179 more antibiotics ($p < 0.0001$).

180 **Discussion**

181 This international survey including 159 surgeons identified 5 major peri-operative
182 factors raised by more than 90% of respondents: to avoid blowing, to avoid valsalva
183 manouver, a resting position of at least 48 hours, a restriction of post-operative activities
184 (scuba diving and bodybuilding), and laxative therapies.

185 Peri-operative management of nasal CSF leaks is not consensual due to limited
186 evidence. Management vary regarding drugs administration, CSF depletion, resting position
187 and limitation of activities. To the best of our knowledge, this study is the largest survey on
188 this topic (level of evidence IV), and the only international one with 35 countries
189 represented. Size and location of the leaks were found to be determining factors for specific
190 peri-operative management of CSF leaks. Extended CSF leaks of the anterior skull base and
191 clival CSF leaks led to recommend a postoperative resting position at least 48 hours in most
192 of cases. These results are consistent with the literature [13,16] that found high-flow and
193 extended leaks more difficult to achieve a watertight reconstruction [17]. Postoperative bed
194 rest was considered by 90% of respondents, mainly in Fowler's position. It allows a better
195 regulation of the ICP which is close to zero in this position [18] and thus is a good
196 compromise of lowering ICP without risk of pneumocephalus due to ball-valve effect [17]. An
197 increase ICP is a well-known risk factor of recurrence of CSF leaks [13], but the
198 pathophysiology of CSF dynamics remains multifactorial and not fully understood [19].
199 Increased ICP would notably imply the presence of transverse venous sinus stenosis, found
200 to be a risk factor for spontaneous nasal CSF leak [3].

201 CSF depletion is another way to decrease ICP according to the Monro-Kellie doctrine
202 stating that the combined volume of neuronal tissue, blood and CSF is constant [20]. Lumbar
203 drain was mainly considered by the panel, but there is no evidence or recommendation for a

204 routine use in small or low-flow defects [15]. Only one randomized controlled trial showed
205 reduced postoperative CSF leak with lumbar drainage in case of high-risk defects (mainly
206 extended or in the middle cranial base) [21]. In our study, 33% of respondents used lumbar
207 punctures pre- or peroperatively and 25% postoperatively. The size of the defect was one of
208 the determining factors to perform CSF depletion as well as an increased ICP. Most of
209 respondent used CSF depletion in case of recurrence of the rhinorrhea or decision to
210 perform a revision surgery.

211 Postoperative antibiotics were used to prevent infectious complication by 74.5% of
212 respondents, mainly ENT, despite the risk of masking nosocomial meningitis. 92% of
213 respondents considered using medication to maintain or reduce the ICP and facilitate
214 healing of the reconstruction site. Acetazolamide was the preferred molecule of the panel,
215 which was systematically used by 12% of respondents. This is the only drug which has
216 proven its efficiency to manage postoperative ICP [22] (grade C) in the literature. An
217 increased abdominal pressure [18,23] is also one of these triggering factors; thus, the
218 prevention of its raise could limit the recurrence rate. In our study, 88% of respondents used
219 laxative therapy to minimize the abdominal efforts during defecation. However, there is no
220 data available on the efficiency of this medication [24].

221 Concerning the patient postoperative return to activities, our panel recommend
222 delaying the resumption of plane travel (78%) and driving (44%). This was in lower
223 proportion than previous data published in north America, where skull base surgeons
224 restricted these activities in an almost unanimous way [15,25]. We also found a similar rate
225 of diving or swimming restrictions which were contraindicated by the majority of
226 respondents because at risk of pneumocephalus due to pressure constraints on the skull
227 base reconstruction [26]. Bodybuilding was also contraindicated by more than 90% of

228 respondents, and 20% of respondents maintained this contraindication for life. This is of
229 particular interest because Haykowsky et al. [27] showed that resistance exercises, as
230 bodybuilding, raise the ICP in healthy volunteers. Some authors also suggest that repeated
231 Valsalva maneuvers in chronic weight lifting exercises could lead to empty sella syndrome due
232 to a chronic increased ICP [28]. Consistent with the literature [15,25], all respondents limited
233 the use of CPAP postoperatively that is associated to a higher recurrence rate of the leaks by
234 destabilizing the reconstruction [29], but there was no consensus on the duration of this
235 restriction.

236 Although the large panel of responding surgeons may appear representative of the
237 international population of surgeons, opinion surveys are limited in a number of ways. Most
238 practices regarding peri-operative management of nasal CSF leaks are guided by team habits
239 and few clinical data are available. It also remains difficult for surgeons to answer the
240 questions when a case-by-case decision is common in EESBS. Nevertheless, the survey
241 design tried to limit these biases by achieving precise questions according to the size and
242 location of the leaks, and a free text answer was available for each question.

243 **Conclusion**

244 This international survey revealed differences in opinion between ENT surgeons and
245 neurosurgeons, it highlights some consensual practice in the perioperative management of
246 nasal CSF leaks.

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333 **Tables**334 **Table 1:** Demographics of respondents.335 *ENT: Ear, Nose and Throat surgeons.*

| | ENT, n (%) | Neurosurgeons, n (%) | Total, n (%) |
|--|-------------------|-----------------------------|---------------------|
| | 124 (81) | 29 (19) | 153 (100) |
| Country | | | |
| France | 29 (23.4) | 13 (44.8) | 42 (27.5) |
| Italy | 12 (9.7) | 5 (17.2) | 17 (11.1) |
| United Kingdom | 8 (6.5) | 6 (20.7) | 14 (9.2) |
| Spain | 10 (8.1) | 0 (0) | 10 (6.5) |
| Germany | 5 (4.0) | 1 (3.5) | 6 (3.9) |
| Portugal | 6 (4.8) | 0 (0) | 6 (3.9) |
| Belgium | 5 (4.0) | 1 (3.5) | 6 (3.9) |
| Switzerland | 5 (4.0) | 0 (0) | 5 (3.3) |
| Russia | 3 (2.4) | 1 (3.5) | 4 (2.6) |
| Austria | 3 (2.4) | 0 (0) | 3 (2.0) |
| Greece | 3 (2.4) | 0 (0) | 3 (2.0) |
| Other European countries (1 or 2 respondents) | 15 (12.1) | 0 (0) | 15 (9.8) |
| Brazil | 6 (4.8) | 0 (0) | 6 (3.9) |
| USA | 2 (1.6) | 0 (0) | 2 (1.3) |
| Russia | 3 (2.4) | 1 (3.4) | 4 (2.6) |
| Other non-European countries (1 respondent) | 9 (7.3) | 1 (3.4) | 10 (6.5) |
| Practice | | | |
| University Hospital | 98 (79.0) | 19 (65.5) | 117 (76.5) |
| Public non-academic | 20 (16.1) | 10 (34.5) | 30 (19.6) |
| Private | 16 (12.9) | 0 (0) | 16 (10.5) |
| Proximity of ENT and Neurosurgery units | | | |
| Same building | | 89 (58.2) | |
| Another building | | 44 (28.7) | |
| No proximity | | 20 (13.1) | |
| Experience in endoscopic skull base surgery | | | |
| < 5 years | 48 (38.7) | 11 (37.9) | 59 (38.6) |
| 5-9 years | 24 (19.4) | 8 (27.6) | 32 (20.9) |
| 10-14 years | 12 (9.7) | 6 (20.7) | 18 (11.8) |
| 15-19 years | 15 (12.1) | 2 (6.9) | 17 (11.1) |
| 20 years or more | 26 (21.0) | 2 (6.9) | 28 (18.3) |

336

337 **Table 2:** Post-operative advice for the healing.

338 *CPAP: Continuous Positive Airway Pressure device*

| Post-operative advice | n (% [CI95]) |
|---|---------------------------------|
| Avoid blowing | 138 (90.2% [85.5-94.9]) |
| Avoid Valsalva manoeuvre | 140 (91.5% [87.1-95.9]) |
| Avoid leaning forward | 76 (49.7% [41.8-57.6]) |
| Avoid inhaling sharply through the nose | 46 (30.1% [22.8-37.3]) |
| Saline irrigations | 120 (78.4% [71.9-85.0]) |
| Duration of advice | |
| < 2 weeks | 12 (7.8% [3.6-12.1]) |
| 2-4 weeks | 110 (71.9% [64.8-79]) |
| > 4 weeks | 26 (17% [11-23]) |
| Delay in the use of CPAP | |
| < 2 weeks | 17 (11.1% [6.1-16.1]) |
| 2-4 weeks | 76 (49.7% [41.8-57.6]) |
| > 4 weeks | 33 (21.6% [15.1-28.1]) |
| Variable: according to healing status / leak size | 8 (5.2% [1.7-8.8]) |

339

340 **Table 3:** Post-operative activities restrictions. *NA: Not Available*

| Activities (n of respondents) | No restriction N (%[CI95]) | Restriction (%[CI95]) |
|---|--------------------------------|---|
| Driving (n=153) Less than 2 weeks 2-4 weeks 4 weeks or more Variable/Healing Lifetime NA | 86 (56.2% [29.1-44.4]) | 67 (43.8% [35.9-51.7]) 9 (13.4% [5.2-21.6]) 37 (55.2% [43.3-67.1]) 9 (13.4% [5.2-21.6]) 6 (8.9% [2.1-15.8]) 3 (4.5% [0-9.4]) 3 (4.5% [0-9.4]) |
| Running (n=153) 1 month or less 1-3 months 3 months or more Variable/Healing Lifetime NA | 31 (20.3% [13.9-26.6]) | 122 (79.7% [73.4-86.1]) 65 (53.3% [44.4-62.1]) 26 (21.3% [14-28.6]) 16 (13.1% [7.1-19.1]) 6 (4.9% [1.1-8.8]) 7 (5.7% [1.6-9.9]) 2 (1.6% [0-3.9]) |
| Swimming (n=153) 1 month or less 1-3 months 3 months or more Variable/Healing Lifetime NA | 23 (15% [9.4-20.7]) | 130 (85% [79.3-90.6]) 58 (44.6% [36.1-53.2]) 26 (20.0% [13.1-26.9]) 29 (22.3% [15.2-29.5]) 9 (6.9% [2.6-11.3]) 6 (4.6% [1-8.2]) 2 (1.5% [0-3.7]) |
| Free diving (n=149) 1 month or less 1-3 months 3-6 months 6 months or more Variable/Healing Lifetime NA | 10 (6.7% [2.7-10.7]) | 139 (93.3% [89.2-97.3]) 22 (15.8% [9.8-21.9]) 15 (10.8% [5.6-16]) 20 (14.4% [8.6-20.2]) 20 (14.4% [8.6-20.2]) 7 (5.0% [1.4-8.7]) 51 (36.7% [28.7-44.7]) 4 (2.9% [0.1-5.7]) |
| Scuba diving (n=150) 1 month or less 1-3 months 3-6 months 6 months or more Variable/Healing Lifetime NA | 7 (4.7% [1.3-8]) | 143 (95.3% [92-98.7]) 11 (7.7% [3.3-12.1]) 36 (25.2% [18.1-32.3]) 2 (1.4% [0-3.3]) 22 (15.4% [9.5-21.3]) 9 (6.3% [2.3-10.3]) 57 (40.0% [31.8-47.9]) 6 (4.2% [0.9-7.5]) |
| Bodybuilding (n=152) 1 month or less 1-3 months 3-6 months 6 months or more Variable/Healing Lifetime NA | 13 (8.6% [4.1-13]) | 139 (91.4% [87-95.9]) 26 (18.7% [12.2-25.2]) 29 (20.9% [14.1-27.6]) 35 (25.2% [18-32.4]) 12 (8.6% [4-13.3]) 7 (5.0% [1.4-8.7]) 29 (20.9% [14.1-27.6]) 1 (0.7% [0-2.1]) |
| Commercial flights (n=152) 1 month or less 1-3 months 3-6 months 6 months or more Variable/Healing Lifetime NA | 33 (21.7% [15.2-28.3]) | 119 (78.3% [71.7-84.8]) 55 (46.2% [37.3-55.2]) 25 (21.0% [13.7-28.3]) 19 (16.0% [9.4-22.6]) 7 (5.9% [1.7-10.1]) 7 (5.9% [1.7-10.1]) 5 (4.2% [0.6-9.4]) 1 (0.8% [0-0.3]) |

341 **Table 4:** Subgroup analysis on ENT and neurosurgeon populations.

342 *: p < 0.05. ENT: Ear, Nose and Throat surgeons. CSF: Cerebrospinal fluid.

| | ENT surgeons N (% [CI95]) | Neurosurgeons N (% [CI95]) | p-value |
|---|---------------------------------|--------------------------------|----------|
| n | 124 (100%) | 29 (100%) | |
| Surgical techniques | | | |
| Using support material | 35 (28.2% [20.3-36.2]) | 17 (58.6% [40.7-76.6]) | 0.0019* |
| Nasal packing | 104 (83.9% [77.4-90.3]) | 26 (89.7% [78.6-100]) | 0.5703 |
| Resting position | | | |
| No resting position | 8 (6.5% [2.1-10.8]) | 8 (27.6% [11.3-43.9]) | 0.0008* |
| Systematic resting position | 88 (71% [63-79]) | 11 (37.9% [20.3-55.6]) | 0.0008* |
| Administration of drugs | | | |
| Laxative therapy | 112 (90.3% [85.1-95.5]) | 23 (79.3% [64.6-94.1]) | 0.0975 |
| Acetazolamide | 77 (62.1% [53.6-70.6]) | 9 (31% [14.2-47.9]) | 0.0024* |
| Pneumococcal vaccine | 69 (55.6% [46.9-64.4]) | 19 (65.5% [48.2-82.8]) | 0.3329 |
| Antibiotics | 102 (82.3% [75.5-89]) | 12 (41.4% [23.5-59.3]) | <0.0001* |
| CSF depletion | | | |
| Pre or peroperative | 55 (44.4% [35.6-53.1]) | 13 (44.8% [26.7-62.9]) | 0.9632 |
| Unique lumbar puncture | 16 (29.1% [17.1-41.1]) | 1 (7.7% [0-22.2]) | 0.16 |
| Multiple lumbar punctures | 4 (7.3% [0.4-14.1]) | 2 (15.4% [0-35]) | 0.322 |
| Lumbar drain | 33 (60% [47.1-73]) | 10 (76.9% [54-99.8]) | 0.3451 |
| Postoperative | 83 (66.9% [58.7-75.2]) | 23 (79.3% [64.6-94.1]) | 0.1934 |
| Unique lumbar puncture | 11 (13.3% [6-20.6]) | 2 (8.7% [0-20.2]) | 0.7293 |
| Multiple lumbar punctures | 9 (10.8% [4.2-17.5]) | 6 (26.1% [8.1-44]) | 0.3204 |
| Lumbar drain | 64 (77.1% [68.1-86.2]) | 15 (65.2% [45.8-84.7]) | 0.2468 |
| Postoperative endonasal management | | | |
| Saline irrigations | 96 (77.4% [10.1-84.8]) | 24 (82.8% [69-96.5]) | 0.5291 |
| Postoperative debridement | 88 (71% [63-79]) | 7 (24.1% [8.6-39.7]) | <0.0001* |
| Follow-up after discharge | | | |
| Systematic imaging | 69 (55.6% [46.9-64.4]) | 22 (75.9% [60.3-91.4]) | 0.0459* |

344 **Table 5:** Subgroup analysis according to surgeons' experience.

345 *: p < 0.05. ENT: Ear, Nose and Throat surgeons.

| | < 10 years of experience n (% [CI95]) | 10 years or more of experience n (% [CI95]) | p-value |
|------------------------------------|--|--|---------|
| n | 91 (100%) | 62 (100%) | |
| Surgical techniques | | | |
| Using support material | 61 (67% [57.4-76.7]) | 45 (72.6% [61.5-83.7]) | 0.4652 |
| Nasal packing | 82 (90.1% [84-96.2]) | 48 (77.4% [67-87.8]) | 0.0311* |
| Resting position | | | |
| No resting position | 8 (8.8% [3-14.6]) | 8 (12.9% [4.6-21.3]) | 0.6211 |
| Systematic resting position | 65 (71.4% [62.2-80.7]) | 34 (54.8% [42.5-67.2]) | 0.035* |
| Administration of drugs | | | |
| Laxative therapy | 80 (87.9% [81.2-94.6]) | 55 (88.7% [80.8-96.6]) | 0.8805 |
| Acetazolamide | 57 (62.6% [52.7-72.6]) | 29 (46.8% [34.4-59.2]) | 0.0522 |
| Pneumococcal vaccine | 48 (52.7% [42.5-63]) | 40 (64.5% [52.6-76.4]) | 0.1482 |
| Antibiotics | 72 (79.1% [70.8-87.5]) | 42 (67.7% [56.1-79.4]) | 0.1128 |
| CSF depletion | | | |
| Pre or peroperative | 45 (49.5% [39.2-59.7]) | 23 (37.1% [25.1-49.1]) | 0.0244* |
| Unique lumbar puncture | 7 (15.6% [5-26.2]) | 10 (43.5% [23.2-63.7]) | 0.2627 |
| Multiple lumbar punctures | 4 (8.9% [0.6-17.2]) | 2 (8.7% [0-20.2]) | 1 |
| Lumbar drain | 32 (71.1% [57.9-84.4]) | 10 (43.5% [23.2-63.7]) | 0.0265* |
| Postoperative | 62 (68.1% [58.6-77.7]) | 44 (71% [59.7-82.3]) | 0.7089 |
| Unique lumbar puncture | 7 (11.3% [3.4-19.2]) | 6 (13.6% [3.5-23.8]) | 0.7167 |
| Multiple lumbar punctures | 9 (14.5% [5.8-23.3]) | 6 (13.6% [3.5-23.8]) | 0.8981 |
| Lumbar drain | 47 (75.8% [65.2-86.5]) | 32 (72.7% [59.6-85.9]) | 0.72 |
| Postoperative endonasal management | | | |
| Saline irrigations | 73 (80.2% [72-88.4]) | 47 (75.8% [65.2-86.5]) | 0.5147 |
| Postoperative debridement | 54 (59.3% [49.3-69.4]) | 41 (66.1% [54.4-77.9]) | |
| Follow-up after discharge | | | |
| Systematic imaging | 62 (68.1% [58.6-77.7]) | 29 (46.8% [34.4-59.2]) | 0.0082* |

346

347 **Table 6:** Subgroup analysis on academic and non-academic practices populations. *: p < 0.05.

348 ENT: Ear, Nose and Throat surgeons.

| | Academic practice n (% [CI95]) | Non-academic practice n (% [CI95]) | p-value |
|-----------------------------|-----------------------------------|---------------------------------------|---------|
| n | 117 (100%) | 36 (100%) | |
| Surgical techniques | | | |
| Using support material | 85 (72.6% [64.6-80.7]) | 21 (58.3% [42.3-74.4]) | 0.1035 |
| Nasal packing | 98 (83.8% [77.1-90.4]) | 32 (88.9% [78.6-99.2]) | 0.5972 |
| Resting position | | | |
| No resting position | 10 (8.5% [3.5-13.6]) | 6 (16.7% [4.5-28.8]) | 0.1639 |
| Systematic resting position | 75 (64.1% [55.4-72.8]) | 24 (66.7% [51.3-82.1]) | 0.7783 |
| Administration of drugs | | | |
| Laxative therapy | 103 (88% [82.2-93.9]) | 32 (88.9% [78.6-99.2]) | 1 |
| Acetazolamide | 69 (59% [50.1-67.9]) | 17 (47.2% [30.9-63.5]) | 0.2139 |
| Pneumococcal vaccine | 73 (62.4% [53.6-71.2]) | 15 (41.7% [25.6-57.8]) | 0.0278* |
| Antibiotics | 87 (74.4% [66.5-82.3]) | 27 (75% [60.9-89.2]) | 0.9385 |
| CSF depletion | | | |
| Pre or peroperative | 51 (43.6% [34.6-52.6]) | 17 (47.2% [30.9-63.5]) | 0.7013 |
| Unique lumbar puncture | 13 (25.5% [13.5-37.5]) | 4 (23.5% [3.4-43.7]) | 1 |
| Multiple lumbar punctures | 6 (11.8% [2.9-20.6]) | 0 (0%) | 0.3246 |
| Lumbar drain | 31 (60.8% [47.4-74.2]) | 12 (70.6% [48.9-92.3]) | 0.4678 |
| Postoperative | 86 (73.5% [65.5-81.5]) | 20 (55.6% [39.3-71.8]) | 0.0412* |
| Unique lumbar puncture | 10 (11.6% [4.9-18.4]) | 3 (15% [0-30.7]) | 0.7079 |
| Multiple lumbar punctures | 15 (17.4% [9.4-25.5]) | 0 (0%) | 0.0686 |
| Lumbar drain | 62 (72.1% [62.6-81.6]) | 17 (85% [69.4-100]) | 0.2717 |
| Postoperative advice | | | |
| Saline irrigations | 93 (79.5% [72.2-86.8]) | 27 (75% [60.9-89.2]) | 0.567 |
| Postoperative debridement | 75 (64.1% [55.4-72.8]) | 20 (55.6% [39.3-71.8]) | 0.3553 |
| Follow-up after discharge | | | |
| Systematic imaging | 67 (57.3% [48.3-66.2]) | 24 (66.7% [51.3-82.1]) | 0.315 |

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