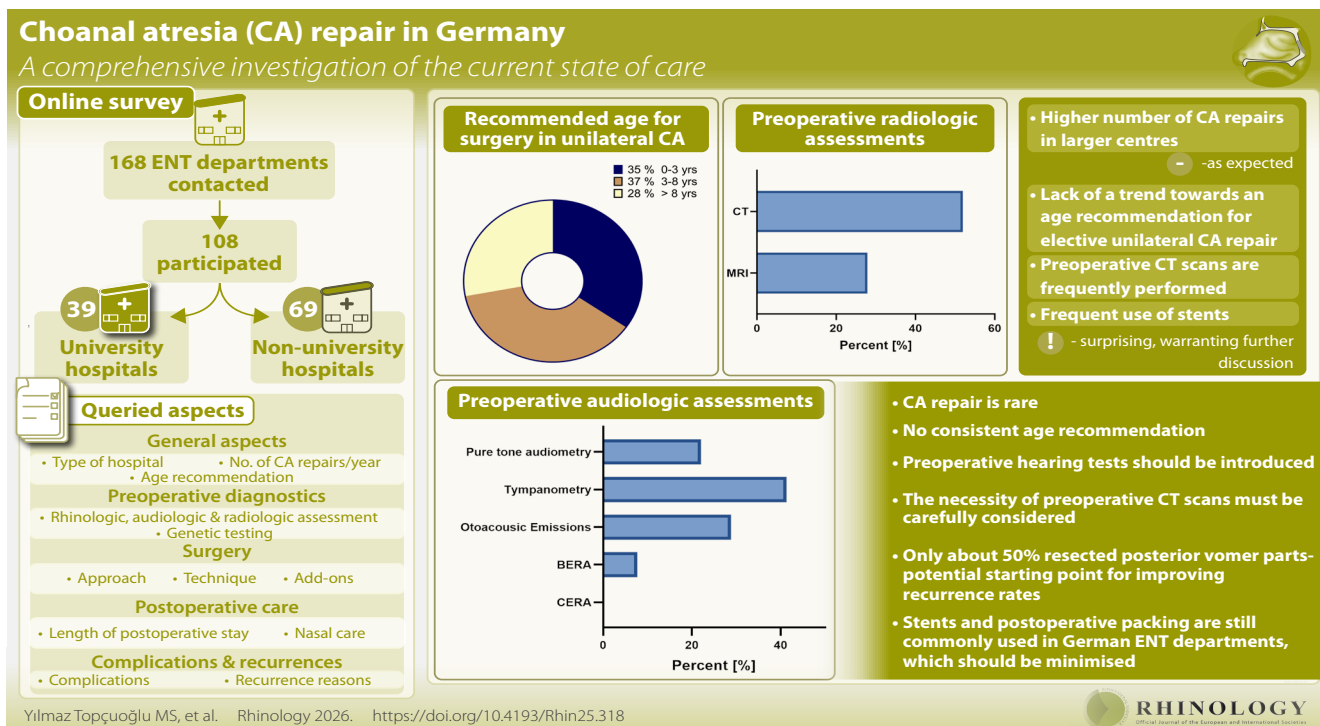


# Choanal atresia repair in Germany – a comprehensive investigation of the current state of care

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## Abstract

**Background:** There is often a discrepancy between official recommendations and actual clinical practice on repair of congenital choanal atresia (CA). The objective of this study was to evaluate the current state of care for CA patients in Germany.

**Methods:** An online survey was conducted in which 108 German ENT departments were consulted on various aspects of CA management, including preoperative diagnosis, surgical procedures, and postoperative care.

**Results:** 65% of the ENT departments only perform CA repairs at over 3 years of age. Flexible nasal endoscopy (69%), hearing tests (41%), and computed tomography (52%) were preoperative diagnosis tools. Posterior vomer was resected in 56% of the ENT departments. Scar- (60%), granulation tissue (38%), and insufficient vomer resections (21%) caused recurrences. Stents were used by 38%.

**Conclusions:** Elective unilateral CA repair should be performed in time to minimise symptoms. Preoperative hearing tests should be introduced as routine to identify CA patients with hearing problems. The utilisation of preoperative computed tomography should be discussed individually. Only just over half of the participating ENT departments resected posterior vomer parts. This is a significant starting point with the potential to improve the recurrence rates of this patient cohort. Stent use is still quite common in Germany. This should be changed in the future.

**Key words:** choanal atresia, diagnosis, postoperative care, surgery, survey

## Introduction

As congenital choanal atresia (CA) is a rare pathology, many Ear-Nose-Throat (ENT) surgeons are not familiar with the management of these cases<sup>(1)</sup>. To optimally treat this vulnerable patient cohort, who often suffer from comorbidities, it is important to have a clear scheme and approach in order to handle these patients effectively<sup>(1-4)</sup>.

A preliminary study on CA repair in Germany was conducted in 2024, with a particular focus on the utilisation of stents and the prevalence of posterior vomer resection<sup>(5)</sup>. This study demonstrated that 89% (39/44) of the participating German ENT departments resect posterior vomer parts. 42% (20/48) stated, they would not use stents, while 44% (21/48) indicated that they would use stents. The limitations of this study were, firstly, a mere 48 hospitals responded to the survey, thus precluding the ability to provide a comprehensive response for all ENT departments in Germany. Secondly, the focus of the inquiry was exclusively on the surgical aspects of posterior vomer resections and the utilisation of stents. However, the scope of CA management extends beyond this, encompassing the pre- and postoperative periods. Thirdly, there was a significant potential for interviewer and response bias, as the ENT departments were contacted directly by email to participate in the study and there was no option to participate anonymously<sup>(5)</sup>.

There are excellent, high-quality consensus papers with comprehensive recommendations on the management of CA patients, compiled by experts through a consensus process<sup>(4,6)</sup>. However, these recommendations do not necessarily reflect everyday clinical practice. A clinical perspective on the implementation of these recommendations is still pending. The aim of this study was to provide a comprehensive overview of current practices for patients with CA in Germany, from preoperative diagnostics to surgical techniques and postoperative management. The intention was to explore the practical aspects that need to be improved in future, and to establish a basis for further discussion and communication about how the management of CA patients can be optimised. The management of CA patients is not uniform across many countries, which makes this also of interest to the international paediatric ENT community.

## Materials and methods

### Survey

All 168 German ENT departments listed on the official website of the German Society of Oto-Rhino-Laryngology, Head and Neck Surgery as officially recognised ENT departments in hospitals as of 1 June 2024 were considered for participation in the study. The initial communication with each ENT department was via a general email sent to the head of department, inviting them to participate in the survey and providing a link to it. The study period was from June 2024 to March 2025. The LimeSurvey online survey tool (LimeSurvey GmbH, LimeSurvey Community

Edition, Version 6.13.2+250506) was used. The management of patients with congenital CA was queried with regard to different demographic, preoperative, surgical and postoperative aspects (Table 1).

A total of 108 ENT departments (64%) voluntarily participated in the online survey. The study did not involve single patient data. The ENT departments taking part were made up of ENT departments from university hospitals (n = 39) and non-university hospitals (n = 69). To better control for interviewer- and response bias, the participants had the option of taking part in the survey anonymously. There were two obligatory questions: the type of hospital (university hospital, urban area hospital with or without maximum care, community hospital, or other with the option to specify) and the estimated number of CA repairs performed per year. All other questions were optional, so the number of responses per question ranged from a minimum of 71 to a maximum of 108. The number of responses received for each question is documented in the results section.

### Statistical analysis

The data were analysed using GraphPad Prism version 10.4.0 (GraphPad Software, Boston, MA, USA). Data are presented as the mean  $\pm$  standard deviation; 95%-confidence interval, or as absolute and relative numbers [%]. A t-test was used to statistically compare the number of CA repairs performed per year. The significance level was set to  $p < 0.05$ .

## Results

### Choanal atresia repairs are rare and there is no uniform age recommendation for elective repair of unilateral choanal atresia

On average,  $3.1 \pm 3.2$ ; 2.5-3.7 CA repairs (108 responses) were performed per year in German ENT departments. University hospitals perform significantly more CA repairs than non-university hospitals each year ( $4.6 \pm 3.5$ ; 3.5-5.8 vs.  $2.2 \pm 2.6$ ; 1.5-2.8;  $p < 0.001$ ).

Of the participating ENT departments, 35% perform elective repair of unilateral CA in patients under three years of age, 37% perform CA repair in patients aged three to eight years, and 28% in patients over eight years of age (81 responses) (Figure 1).

### The main diagnostic methods were preoperative nasal endoscopy and computed tomography

The performance of preoperative examinations of the nose, hearing, radiology and genetics was assessed (Figure 2). Flexible nasal endoscopy was the main procedure performed during clinical examinations (69%, 72/104). Preoperative hearing testing was performed using tympanometry in 41% (43/104) of the German ENT departments, otoacoustic emissions in 29% (30/104), and pure-tone audiometry in 22% (23/104), depending on feasibility and the age of the patient. Brainstem-evoked

Table 1. Queried aspects in the online survey on management of choanal atresia in Germany.

General aspects	Preoperative diagnostics	Surgery	Postoperative care	Complications & recurrences
<b>Type of hospital*</b>	<b>Rhinologic assessment</b>	<b>Approach</b>	<b>Length of postoperative stay</b>	<b>Complications</b>
university, urban with/without maximum care, community, other with option to specify	flexible/rigid nasal endoscopy, anterior rhinoscopy, rhinomanometry, olfactory/mirror test	transnasal endoscopic, transseptal, transpalatinal		Bleeding, treated surgically/conservatively, granulation tissue, palate perforation
<b>Number of CA repairs/year*</b>	<b>Audiologic assessment</b>	<b>Technique</b>	<b>Nasal care</b>	<b>Recurrence reasons</b>
	PTA, tympanometry, OAE, BERA, CERA	Vomer resection, mucosal flap elevation	isotonic/hypertonic saline/topical corticosteroids application, daily suctioning/nasal endoscopy, postoperative antibiotics	scar/granulations tissue, bony-membranous/bony restenosis, insufficient vomer resection/resection to nasal floor/to clivus/laterally/medially
<b>Age recommendation</b>	<b>Radiologic assessment</b>	<b>Add-ons</b>		
for elective repair of unilateral CA	CT, MRI	Stents & time to removal, packing, mitomycin C, DES		
	Genetic testing			

\*Obligatory questions, all other questions could be answered on a voluntary basis; CA: choanal atresia, PTA: pure-tone audiometry, OAE: otoacoustic emissions, BERA: brainstem-evoked response audiometry, CERA: cortical-evoked response audiometry, CT: computed tomography, MRI: magnetic resonance imaging, DES: drug-eluting stents.

response audiometry was used in 8% (8/104) of the German ENT departments, and cortical-evoked response audiometry in none (0/104). Preoperative computed tomography (CT) scans were performed in 52% (54/104) of the ENT departments, while magnetic resonance imaging (MRI) scans were performed in 28% (29/104). Only 3% (3/104) of the participating ENT departments performed preoperative genetic testing.

**Transnasal endoscopic choanal atresia repair was the approach of choice, and elevating mucosal flaps was not common**

The transnasal endoscopic approach for CA repair was employed by 77% (73/95) of the participating German ENT departments. Transseptal approach was performed by 16% (15/95) and transpalatinal approach by 6% (6/95) of the German ENT

departments. Vomer resection was performed in 56% (53/95) of the ENT departments, while mucosal flap elevation was performed in 25% (24/95).

**Stents were still in use, the postoperative stay was short, and isotonic saline was the main postoperative care measure**

38% (29/77) of the ENT departments always or mostly used stents after CA repair. The stents were removed after an average of 5.6 ± 6.0; 4.1-7.1 weeks following CA repair. 34% (26/77) of the participating ENT departments hardly or never used stents after CA repair (Figure 3). Postoperative packing was performed by 23% (22/95), topical mitomycin was applied by 3% (3/95), and drug-eluting stents were used by 6% (6/95) of the ENT departments.

The postoperative stay was two nights in 54% (38/71) of the ENT departments and three nights in 28% (20/71) of the ENT departments. The main postoperative nasal care measurements after transnasal endoscopic or transseptal CA repair were isotonic saline (58%, 53/92), daily suctioning (37%, 34/92), and topical corticosteroids (32%, 29/92) (Table 2). Only 6% of the ENT departments that performed transpalatinal CA repair used postoperative nasal care.

**Choanal atresia repair had few complications and granulation tissue growth and insufficient posterior vomer resection**

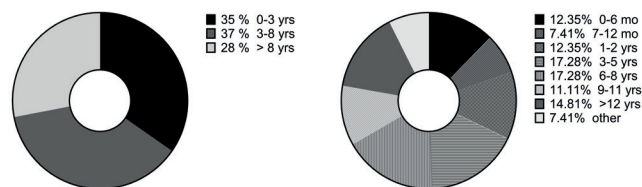


Figure 1. Recommended ages for elective repair of unilateral choanal atresia. The left panel plots the age distribution of choanal atresia patients for under 3 years, 3–8 years, and over 8 years. The right panel shows the exact distribution.

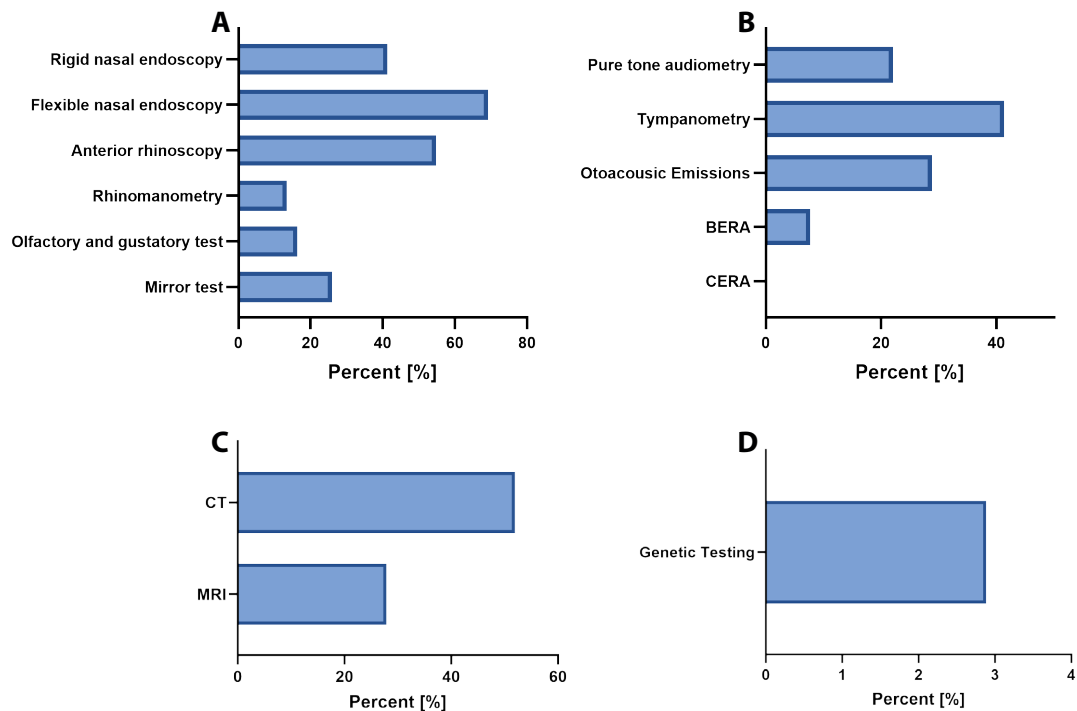


Figure 2. Preoperative diagnostics in patients with choanal atresia. A) Rhinologic assessments, B) Audiologic assessments, C) Radiologic assessments, D) Genetic testing. BERA: brainstem-evoked response audiometry, CERA: cortical-evoked response audiometry, CT: computed tomography, MRI: magnetic resonance imaging.

**caused recurrences**

As postoperative complications, 49% (45/91) reported of granulation tissue growth (80% transnasal endoscopic, 16 % transseptal, 4% transpalatinal approaches). 19% (17/91) reported of local bleeding that could be managed conservatively (59% transnasal endoscopic, 35% transseptal, 6% transpalatinal approaches). Surgical management was required for bleedings in only 3% (3/91) of the departments (33% transnasal endoscopic, 67% transseptal approaches). Palate perforations occurred in 2% (2/91) of the departments, that performed transnasal endoscopic CA repair. Scar tissue (60%, 55/91), granulation tissue (38%, 35/91) and insufficient vomer resections (21%, 19/91) were reported to be the leading reasons for recurrences.

**Discussion**

This study aimed to investigate the current clinical practice of CA management in German ENT departments, examining it against the backdrop of existing recommendations (4, 6). Furthermore, the aim was to establish a platform for ongoing communication and discussion on how to improve care for patients with CA, given that CA is not commonly encountered in ENT departments and there is no standardised procedure. While some aspects, such as the higher number of CA repairs in larger centres, were as expected, others, such as the lack of a trend towards an age recommendation for elective unilateral CA

repair and the frequent use of stents, were surprising and warrant further discussion.

The results showed that university hospitals performed significantly more CA repairs than non-university hospitals. This is to be expected, as ENT departments in major centres are linked to children's hospitals, meaning patients are more likely to have paediatric diseases and associated abnormalities. Regarding the recommended age for elective repair of unilateral CA, no clear trend emerged among the German ENT departments (Figure 1). As repair of unilateral CA is not an emergency procedure, the timing of surgery should generally be determined on a case-by-case basis, depending on existing symptoms (1, 4, 7). Brihaye et al. recommended performing unilateral CA repair in a timely manner after diagnosis, regardless of the patient's age, to relieve nasal obstruction and chronic paranasal and serous otitis media infections as soon as possible (8). Additionally, it has been reported that the atresia plate can thicken over time (9). Therefore, resection of the bony CA was more invasive as the child got older (9). By contrast, Moreddu et al. and Urbancic et al. recommend an age of at least six months for elective CA repair (4, 6). Also, Hengerer et al. and Hackenberg et al. suggest an age range of six to twelve months (10, 11). The authors of this paper agree with these recommendations, as anatomy has advanced to the point where the nose is more accessible for endoscopic surgery, and general anaesthesia is safer

Table 2. Postoperative nasal care practices in German ENT departments following CA repair.

Method	Absolute numbers	Relative numbers [%]
Isotonic saline application	53/92	58
Daily suctioning	34/92	37
Topical corticosteroids	29/92	32
Daily nasal endoscopy	17/92	18
Postoperative systemic antibiotics	12/92	13
Hypertonic saline application	5/92	5

ENT: Ear Nose Throat, CA: choanal atresia. This was a multiple-choice question, so several responses could be chosen by the study participants.

for older children than for neonates<sup>(12)</sup>. The age recommendation for elective CA repair in unilateral CA should be discussed further, as 65% of the German ENT departments only perform these repairs at over 3 years of age. Thus, many children and their families may have experienced impairing symptoms for a long time. Early repair of unilateral CA is considered beneficial for patients as there is a correlation between delayed CA repair and upper jaw growth disorders<sup>(13,14)</sup>. Furthermore, in the long term, the olfactory performance of the affected side can be significantly reduced due to insufficient neuroplasticity during the early childhood stage of brain development, caused by unilateral nasal obstruction and reduced olfactory input<sup>(15,16)</sup>. Thus, timely CA repair might improve lifelong olfactory performance<sup>(15,16)</sup>.

Another aspect investigated was the preoperative diagnostic measurements performed. As infants and younger children often dislike clinical examinations, the least invasive and time-consuming examination method should be the method of choice. Regarding local nasal diagnostics, flexible nasal endoscopy was the main examination method and should continue to be used as a diagnostic tool, as recommended by Moreddu et al. and Urbancic et al.<sup>(4,6)</sup>. It provides sufficient visualisation following nasal decongestion and suctioning of nasal secretions<sup>(17-19)</sup>. Other diagnostic tests, such as rhinomanometry, olfactory or gustatory tests, and the mirror test, were not commonly used in the included ENT departments. Some authors report using the mirror test<sup>(17-19)</sup>. Nevertheless, measurements as olfactory testing or rhinomanometry have not yet become practice, as these tests are not be feasible for the paediatric patients before school age and these tests do not add any value to diagnosis of CA. Since 2009, all neonates in Germany have received a new-born hearing screening. Nevertheless, repeated hearing tests may reveal hearing impairments after birth, so hearing assessments could be useful, as patients with CA may also suffer from serous

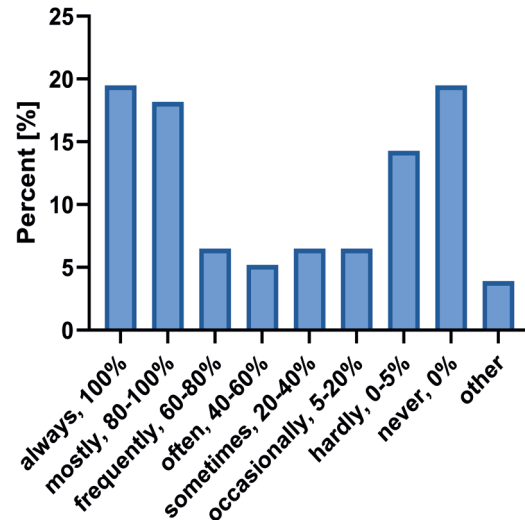


Figure 3. Use of stents following choanal atresia repair in German ENT departments. The distribution of stent use from always to never is demonstrated in percent [%]. Total number of responses n = 77. ENT: ear nose throat.

otitis media<sup>(8)</sup>. Preoperative hearing tests were not a common practice in the German ENT departments. A maximum of only 41% have carried out preoperative tympanometry. Pure tone audiometry is not feasible for all children depending on their age, but other objective hearing tests such as otoacoustic emissions or brainstem evoked response audiometry could complement the preoperative hearing assessment. The authors have experienced benefits for patients with CA and poor ventilation when concomitant surgical procedures such as adenoidectomies or paracenteses/ventilation tube insertions were performed (if indicated by symptoms and hearing tests). This is why, in the authors' department, otoacoustic emissions and tympanometry are routinely performed prior to CA repair. If feasible, depending on the patient's age, pure tone audiometry is also performed. One future goal should be to increase the number of preoperative hearing tests performed before CA repair. Moreddu et al. and Urbancic et al. also recommend age- and function-adapted hearing tests for CA patients<sup>(4,6)</sup>.

Despite the potential risks associated with radiation exposure<sup>(20)</sup>, more than half of the participating departments routinely performed preoperative computed tomography scans, while only 28% performed preoperative MRI scans. Many authors recommend CT for diagnosis and surgical planning<sup>(1,2,4,6,21)</sup>. Imaging improves safety and planning capabilities of surgery<sup>(22,23)</sup>. Still, next to the radiation exposure in CT scans, imaging in young children often requires general anaesthesia. As radiation exposure should be minimised for this vulnerable patient group<sup>(20)</sup>, and CA repair can be clearly visualised using endoscopes<sup>(18,19,24)</sup>, the authors personally believe that the number of preoperative CT scans in patients with CA could be significantly

reduced. MRI scans also provide sufficient information on potential comorbidities and the local anatomy, without exposure to radiation. The decision to perform preoperative MRI or CT imaging should be made on an individual basis, depending on the surgeon's expertise, the child's state of health and comorbidities, and the evaluation of the expected risk-benefit ratio. Fitzpatrick et al. suggested, that preoperative imaging is unnecessary for the sole purpose of surgically repairing unilateral, non-syndromic CA, provided that preoperative nasal endoscopy examinations reveal normal anatomy<sup>(23)</sup>.

In the German ENT departments, preoperative genetic testing was rarely performed. Genetic testing is expensive, and not all genetic defects that cause CA might be already known. Therefore, performing genetic testing solely on the basis of a CA diagnosis might not be purposeful. The authors agree with Moreddu et al. and Urbancic et al. that genetic consultations should only be performed in selected cases, bilateral CA or cases where syndromic comorbidity is highly suspected<sup>(4, 6)</sup>. Patients with bilateral CA often present with CHARGE syndrome (coloboma, heart defect, atresia choanae, retarded growth and development, genital abnormality, ear abnormality) or other comorbidities, and have already received genetic testing from the paediatric department. Preoperative cardiac assessments are strongly recommended for patients with bilateral CA, as well as for other selected cases where cardiac disease is suspected. Their purpose is to detect and treat potential anaesthetic risks before CA repair<sup>(4, 6)</sup>.

The transnasal endoscopic approach was the primary method employed in German ENT departments. This is in line with international recommendations and consensus papers<sup>(2, 4-6, 8)</sup>. Endoscopic CA repair is a safe procedure that provides good visualisation and has a low complication rate<sup>(8, 25-28)</sup>. Therefore, it should remain the preferred approach.

Only just over half (56%) of the study participants resected posterior parts of the vomer as standard technique. This is surprising given that it is well known that insufficient vomer resection causes recurrence<sup>(8, 29-31)</sup>. Also, the ENT departments participating in this study identified insufficiently resected vomer parts as the third most common cause of recurrence. As the aim is to achieve a successful single-stage CA repair and minimise the need for revision surgeries<sup>(8, 32)</sup>, this is an area on which future efforts to optimise CA patient treatment should focus.

Many authors have reported good outcomes for CA repair when elevating mucosal flaps<sup>(8, 19, 27-30, 33-43)</sup>. This technique was not commonly used in German ENT departments, with only one in four stating that they elevate flaps for CA repair. Moreddu et al. also reported that mucosal flap elevation is not yet common<sup>(4)</sup>. Mucosal flaps are intended to cover exposed bone in order to improve wound healing and reduce the growth of inflammatory granulation tissue<sup>(8, 19, 27-30, 33-42)</sup>. This is an important aspect, as the ENT departments participating in this study identified

granulation tissue and scar tissue growth as the main factors contributing to recurrence. Mucosal flaps may be one key to reducing recurrence based on scar and granulation tissue overgrowth<sup>(8, 19, 27-30, 33-43)</sup>. Further data on the impact of mucosal flap elevation on the outcome of CA repairs is required in order to decide whether or not to implement it as a standard technique<sup>(21, 34, 44)</sup>. This development is reflected in the situation in German ENT departments.

A considerable proportion of participating ENT departments (38%) regularly use stents for an average of six weeks after surgery. It is said that CA repairs involving stents cause more complications than CA repairs without stents<sup>(44, 45)</sup>. A recently published systematic review and meta-analysis by Chowdhury et al. verified that stents cause restenosis and granulation tissue growth<sup>(46)</sup>. The current consensus is that the number of stents used in CA repair should be minimised and reserved for exceptional cases only<sup>(4-6, 18, 32)</sup>. This needs to be implemented more widely in German ENT departments.

The use of topical mitomycin and drug-eluting stents was uncommon in the German ENT departments. There is no evidence to support the use of mitomycin, and given its adverse event profile, it should be avoided<sup>(4, 36, 47)</sup>. ENT surgeons have already reported positive outcomes following CA repair when using self-resorbable drug-eluting stents<sup>(3, 48, 49)</sup>. On the other hand, this is an unproven off-label use and must be used with great care in this vulnerable patient group. Additionally, there is a risk of aspiration into the airway because drug-eluting stents cannot be fixed properly in children's noses.

The average length of postoperative hospital stay was two to three nights, which seems to be a reasonable length of time for children and their families.

For local postoperative care, German ENT departments mainly performed saline applications, daily suctioning and topical corticosteroid treatment. Moreddu et al. and Urbancic and other authors also recommended saline and intranasal corticosteroid application after surgery<sup>(4, 6, 8)</sup>. In line with these recommendations, the use of topical saline and corticosteroid applications should be more widely encouraged in German ENT departments.

Complications were rarely seen in German ENT departments. If they occurred, they were mainly granulation tissue or local bleeding, which could be treated conservatively. In general, CA repair results in few postoperative complications<sup>(8, 26, 30, 50)</sup>. As most bleeding episodes in German ENT departments could be managed conservatively, the use of postoperative packing should be minimised. Currently, 23% of German ENT departments still perform postoperative packing, which may cause discomfort for patients and their parents.

This study had several limitations. It only included German ENT departments. Further examinations should be performed at European and international levels. Some ENT departments that did not participate in the study provided feedback stating that

they do not treat any CA patients at their hospitals. Consequently, only ENT departments with CA patients participated in the study. This may have introduced a selection bias. This study does not claim to be a multicentre study involving a detailed analysis of patients' raw data. This would include information such as the gender distribution of each department's CA patients, whether conditions were unilateral or bilateral, the prevalence of comorbidities or a detailed analysis of correlations between the chosen approaches, postoperative care measures, complications and recurrences. Unfortunately, this was beyond the scope of the present study. Nevertheless, future work should focus on these aspects, as they will certainly provide valuable additional insights.

Furthermore, surveys carry the risk of selection/interviewer/response/recall bias. To control for this bias in this study, ENT departments could complete the survey anonymously on a voluntary basis. Despite the methodological limitations of surveys, they are still important for assessing the current level of care and identifying gaps and research needs.

## Conclusions

This study investigated a broad range of aspects of CA patient management in German ENT departments, considering existing consensus and guideline papers. Several aspects should be discussed or improved in future, while others have already reached a standard level. For example, flexible nasal endoscopy for diagnosis and transnasal endoscopic surgery are already standard in German ENT departments. The postoperative nasal care provided by German ENT departments aligns with international recommendations, but this practice needs to be promoted more widely, as not all departments provide intensive postoperative nasal care. Several further aspects need to be revised. Firstly, CA repair is not performed frequently, and elective unilateral CA repair should generally be performed at an earlier age to reduce symptoms and the risk of chronic infections. Still, a clear age recommendation for when unilateral CA repair should be performed does not exist. Secondly, preoperative hearing tests should be introduced as a routine diagnostic tool for identifying children with hearing problems. Thirdly, the use of preoperative CT for CA is common. Fourthly, only just over half of the participating ENT departments resected posterior vomer parts. This could be a significant starting point for improving the recur-

rence rates of this patient cohort. Fifthly, stents are still used in German ENT departments, and so are postoperative packings, and this practice should be minimised. Mucosal flaps may be one key to reducing recurrence based on scar and granulation tissue overgrowth. Lastly, CA repair involves a relatively short hospital stay and has few complications. Postoperative saline application is a common nasal care measure. The German guideline on the management of CA, which is currently being developed in Germany, aims to raise awareness of the condition, which could improve care for patients with CA.

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## Author contributions

MSYT: conceptualization, data curation, formal analysis, investigation, methodology, project administration, validation, visualization, writing - original draft. PJS: investigation, methodology, validation, writing - review & editing. JHW: methodology, supervision, validation, writing - review & editing. OS: methodology, supervision, validation, writing - review & editing. LW: methodology, validation, writing - review & editing. IB: conceptualization, data curation, investigation, methodology, supervision, validation, visualization, writing - review & editing.

All authors approved the final manuscript before its submission and declare to be accountable for the accuracy and integrity of this work.

## Conflict of interest

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## Availability of data

All data generated or analysed during this study are included in this published article.

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