ORIGINAL ARTICLE

Treatment outcomes in sinonasal aspergillosis in dogs in the United Kingdom: 436 cases (2011-2021)

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Objectives: A variety of treatment options for sinonasal aspergillosis have been described, encompassing non-invasive and invasive approaches. To describe the clinical outcomes in dogs treated for sinonasal aspergillosis in the United Kingdom.

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Materials and Methods: **A multi-centre retrospective survey was performed involving 23 referral centres in the United Kingdom from January 2011 to December 2021. Cases were reviewed for first treatment success rates, the number of treatments required and overall clinical remission rates. Different treatment approaches were compared, including rhinoscopic debridement (RD), trephination (TR) and sinusotomy/rhinotomy (SR).**

Results: **In a cohort of 436 dogs with sinonasal aspergillosis, the most common first treatment modalities were RD (38%) and TR (32%), with SR used in 7% and oral antifungal monotherapy in 3%. The remaining 20% used a mixture of treatments. First treatment remission rate was 55% with SR, 38% with RD, 29% with TR and 31% with the mixed treatment. Overall remission rate was 67% with SR, 81% with RD and 69% with TR and 59% where different treatments were combined. Oral antifungal monotherapy had no successful outcomes at any time point. Complete debridement significantly improved remission rates of first treatments (54% vs. 21%, P = 0.003). Adverse effects were reported in 24% of cases, most commonly in SR and TR groups.**

Clinical Significance: **Rhinoscopic debridement and trephination remain the predominant treatment options for SNA in UK referral practices, with similar overall clinical remission rates. The degree of debridement significantly influences treatment outcomes, with rhinoscopic debridement in combination with topical antifungals showing the highest success rates.**

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INTRODUCTION

Sinonasal aspergillosis (SNA) in dogs is an inflammatory fungal infiltration of the sinonasal and sino-orbital regions (Peeters & Clercx, 2007). Predominantly attributed to *Aspergillus fumigatus*, this condition is a notable contributor to morbidity and mortality among canines (Sykes, 2013).

A variety of treatment options for SNA have been described, encompassing non-invasive approaches including oral antifungal medication or rhinoscopic debridement (with additional measures such as a topical soak and/or depot topical antifungal administration) and invasive approaches including frontal sinus trephination or rhinotomy/sinusotomy (Claeys et al., 2006; Johnson et al., 2006; Vedrine & Fribourg-Blanc, 2018). Although the use of oral antifungals as sole therapy has been described, their limited efficacy and associated adverse effects prohibit reliance on this medication. Clinical improvement has been previously described in 50% to 80% of cases managed by endoscopic debridement (either rhinoscopy or frontal sinus trephination) with adjunctive topical azole therapy (Ballber et al., 2018; Hazuchova et al., 2017; Vedrine & Fribourg-Blanc, 2018). Repeated treatments have also been associated with improved outcomes (Sharman et al., 2010). Meticulous debridement combined with topical antifungal treatment and rhinotomy/sinusotomy had the highest reported rates of clinical resolution (84%), but is markedly more invasive (Hazuchova et al., 2017).

A previous multicentre retrospective comparison of different treatment approaches found no significant differences in outcome between non-invasive and invasive modalities (Sharman et al., 2010). The outcomes were considerably poorer than had been previously reported for treatments performed at single centres (Claeys et al., 2006; Johnson et al., 2006; Sharman et al., 2010; Vedrine & Fribourg-Blanc, 2018). Subsequent studies have tended to focus on single treatment types (or variants thereof) (Claeys et al., 2006; Hazuchova et al., 2017; Johnson et al., 2006). Initial treatment success rates for rhinoscopic debridement and antifungal soak range from 17% to 68%, with a median of two treatments required to achieve a clinical cure and overall success rates ranging from 94% to 100% (Ballber et al., 2018; Hazuchova et al., 2017; Vangrinsven et al., 2018). However, a reduction in the duration of an enilconazole soak from 60 to 15 minutes had no impact on the efficacy of rhinoscopic treatment (Vangrinsven et al., 2018). Initial treatment success rates for rhinotomy and surgical debridement with topical antifungal treatment vary from 57% to 100% (Claeys et al., 2006; Sharp et al., 1993).

Direct comparison between studies is challenging given the application of different outcome definitions and follow-up timeframes. A recent scoping review assessing rhinoscopy and

debridement found no publications reporting a direct comparison and thus no conclusions could be drawn (Belton & Lobb, 2023). The aim of the current retrospective study is to describe the treatment approaches and associated outcomes for dogs diagnosed with SNA and treated in referral practices across the United Kingdom.

MATERIALS AND METHODS

Ethical approval for this study was obtained from the Royal College of Veterinary Surgeons Ethical Review Panel. Data relating to this population of dogs has previously been published in a retrospective study on the clinical characteristics and diagnostic findings of dogs with SNA (Prior et al., 2024).

Diagnostic criteria used for case inclusion are described in Prior et al. (2024). Briefly, dogs were diagnosed with SNA following direct observation of fungal plaques ($n = 419$) or based on the presence of compatible clinical signs, turbinate destruction or sinus involvement on advanced imaging AND at least one positive result from ancillary diagnostic tests ($n = 56$). For each eligible case, the following information relating to treatment modalities was retrieved from the clinical records. The treatment modalities employed in managing SNA in dogs were as follows:

- Oral antifungal medication as monotherapy
- Rhinoscopic debridement (RD) with or without a topical antifungal soak and/or depot administration of an antifungal cream.
- Frontal sinus trephination (TR) ± plaque debridement (via trephination site) ± a topical antifungal soak and/or depot administration of an antifungal cream
- Frontal sinusotomy and/or rhinotomy (SR) ± plaque debridement paired with a topical antifungal soak and/or depot administration of an antifungal cream.
- Surgical implantation of temporary indwelling catheters into the frontal sinus for daily flushing with an antifungal solution.

The completeness of rhinoscopic debridement was categorised as complete when all fungal plaques were entirely removed and partial when residual fungal plaques were present. Dogs were excluded from comparative first treatment analysis where no outcome or treatment details were provided or if they were euthanased without treatment (Fig 1). Treatment types in combination were considered as a mixed category, as were those swapping modalities between treatments. The treatment combinations used are shown in Table S1. Collected data included first treatment outcome (including date of recheck and outcome category), number of treatments performed, final outcome to all (one or more) treatments, time to death and cause of death (SNA-related or unrelated). Additional factors such as extent of debridement achieved and duration of soak were also recorded where available.

Definitions of outcome

Six different outcome categories were defined (complete clinical remission, partial clinical remission, no change (static disease), progressive disease, euthanasia and lost to follow up). Complete clinical remission was defined as the resolution of clinical signs without the need for ongoing treatment.

Clinical remission was assessed after a single treatment (referred to as the first treatment outcome) and in cases where one or more treatments were administered after the last recorded treatment (designated as the final treatment outcome). Clinical relapse was defined as a return of clinical signs.

Statistical analysis

Continuous data are presented as median values with interquartile ranges (IQR). Percentages are calculated based on the final sample of eligible dogs unless otherwise specified or implied. Where the dataset was incomplete, percentages are based on the total number of responses received. Thus, denominators may vary depending on whether a response was received for that question.

Changes across time were assessed by comparing year with mean values in that year using Spearman rank correlation. Because of low numbers of cases, the years 2007/2008/2009/2010 and 2021/2022 were each combined before analysis. Comparisons between categorical variables were made using Fisher exact tests followed, where appropriate, by pairwise tests using the R routine 'pairwiseNominalIndependence'. For ordinal/continuous data, comparisons between two groups were made using Mann–Whitney tests adjusted for ties and for more than two groups using Kruskal–Wallis tests adjusted for ties and where significant, followed by Dunn's multiple comparison tests. The influence of age, weight, sex/neuter status and referral year on success (i.e. complete clinical remission) at final outcome was undertaken in a multiple binary logistic regression, both with and without treatment modality. Goodness of fit was confirmed using Hosmer–Lemeshow tests and lack of collinearity using VIF. Kaplan–Meier survival analysis was performed to evaluate disease-specific (i.e. attributed to SNA) mortality using log-rank tests between groups. Disease-specific mortality was calculated by considering live animals and deaths not attributed to SNA as censored. All analyses were undertaken in Minitab 21 and R 4.3.3. Statistical significance was set at $P < 0.05$.

RESULTS

Of the 475 SNA cases identified in the previous study (Prior et al., 2024), 30 were excluded due to an absence of outcome data, seven dogs had no treatment and two dogs were euthanised with no further treatment. A further 87 cases received combination therapy (e.g. TR and SR) and are considered as a mixed group (Fig 1). The total number of cases included at the end of the first treatment outcome was 436 dogs, which were drawn from 23 different referral centres. There was a median of 11 cases per centre (range 3 to 61).

Computed tomography of the head was performed in 88% (385/436) of cases. Of these, 60% (222/368) had evidence of frontal sinus involvement. Endoscopic debridement was performed in 29% (49/171). Sinus involvement differed between treatment modalities ($P < 0.001$), ranging from 48% for RD to

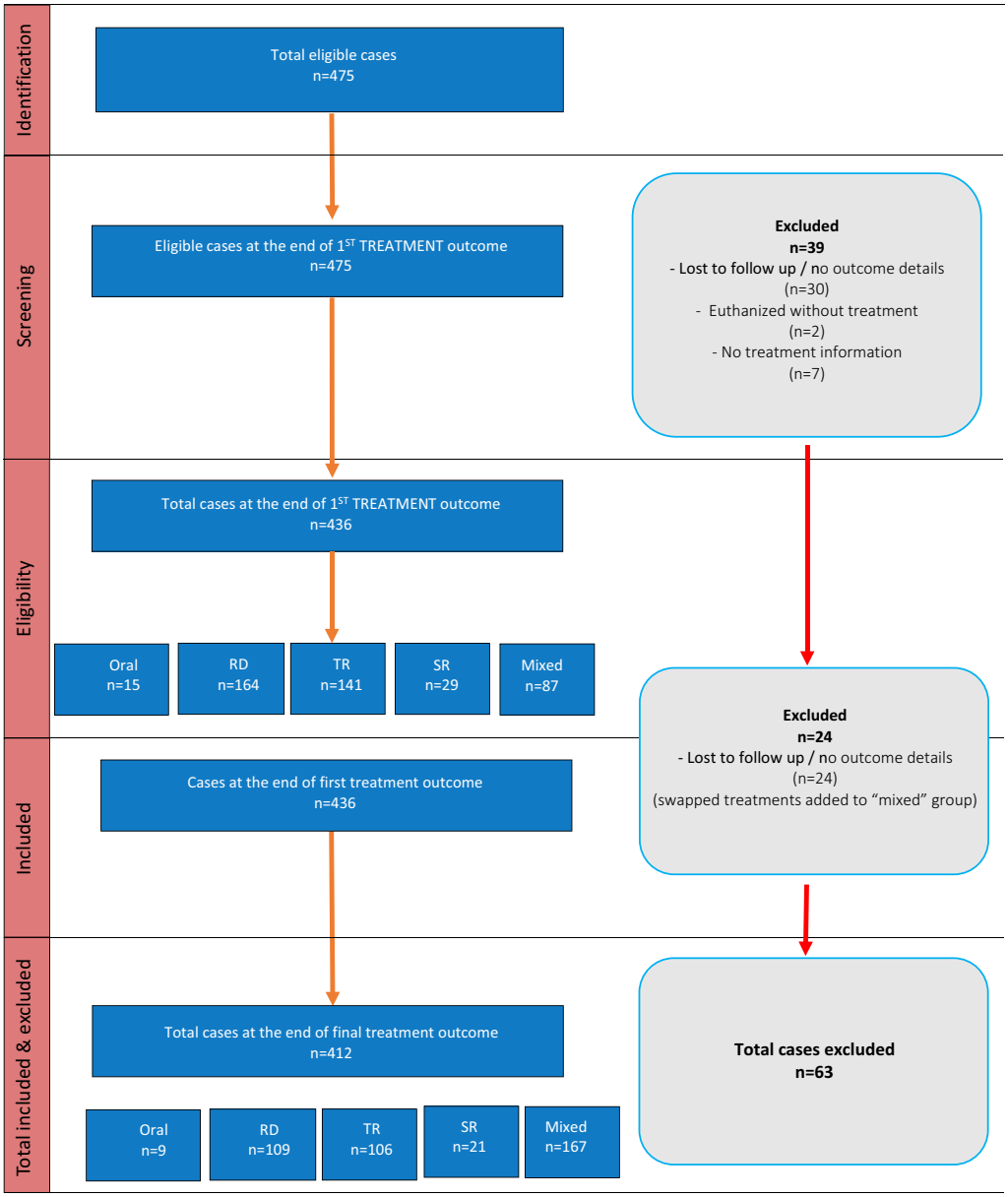

FIG 1. Flow diagram showing the identification, screening and selection of cases.

92% for SR. Temporary indwelling catheters were placed in only seven dogs in this study and always in combination with other treatment modalities.

First treatment outcome

The most employed treatment modalities included RD 38% (164/436) and TR 32% (141/436). Other first treatment approaches included oral antifungal monotherapy 3% (15/436), of which itraconazole was most commonly used 80% (12/15) and SR 7% (29/436). Mixed modalities accounted for the remaining 20% (87/436). Outcomes for each treatment modality after first treatment are shown in Table 1. There was a significant difference in first treatment outcome (clinical remission) between the five treatment groups (P = 0.001, Fisher test). Oral antifungal monotherapy had a significantly lower clinical remission rate 0% (0/15) than all other modalities and SR had a significantly higher clinical remission rate 55% (16/29) than TR 29% (41/141) or mixed 31% (27/87). Across all treatment modalities, clinical remission was significantly lower (27% cf. 42%, P = 0.004) where there was frontal sinus involvement.

Relapse was recorded in 21% (55/258) of dogs that achieved remission. There was no significant difference between relapse rates across all five treatment groups: RD 20% (20/99), TR 18% (15/85), SR 25% (4/16), oral 11% (1/9) and mixed 31% (15/49) (P = 0.443). The median (IQR) time from first treatment to relapse was 245 (105 to 526) days and did not differ significantly between treatment groups (P = 0.466).

Across all treatment groups, completeness of debridement was reported in 48% (140/291) of dogs and described as complete in 80% (112/140) and partial in 15% (21/140). When

Table 1. Baseline characteristics and treatment outcome of SNA to commonly utilised techniques in multiple veterinary referral centres (2011 to 2021)

	Treatment procedure					
	Oral only *n* = 15	Rhinoscopy *n* = 164	Trephination *n* = 141	Sinusotomy/ rhinotomy *n* = 29	Mixed *n* = 87	P
Age (years) – median (IQR)	7.2 (4.0 to 11.6)	5.4 (2.3 to 9.1)	6.1 (3.5 to 9.0)	7.4 (5.1 to 10.6)	6.1 (4.1 to 9.6)	
Weight (kg) – median (IQR)	18 (14 to 30)	28 (19 to 33)	29 (22 to 33)	27 (22 to 31)	27 (23 to 36)	
Days to presentation – median (IQR)	71 (30 to 163)	61 (25 to 105)	65 (32 to 117)	93 (49 to 177)	61 (38 to 102)	
% Female	27%	37%	29%	38%	37%	
Year of referral – median (IQR)	2017 (2014 to 2019)	2018 (2016 to 2020)	2016 (2012 to 2019)	2016 (2011 to 2019)	2016 (2013 to 2019)	
Duration of first hospitalisation (days) – median (IQR)	0 (0 to 1)	1 (1 to 1)	1 (1 to 2)	2 (1 to 3)	1 (1 to 3)	
First treatment success (%)	0%[a] (0/15)	38%[bc] (63/164)	29%[b] (41/141)	55%[c] (16/29)	31%[b] (27/87	0.001
Number of days to first check – median (IQR)	15 (7 to 25)	22 (13 to 32)	21 (14 to 28)	27 (16 to 40)	23 (13 to 37)	
Sinus involvement	67% (8/12)	48% (70/145)	65% (71/109)	92% (22/24)	65% (51/78)	
Mortality First treatment	1 (7%)	1 (1%)	5 (4%)	0 (0%)	4 (5%)	
End of study	*n* = 9	*n* = 109	*n* = 106	*n* = 21	*n* = 167	
Final treatment success (%)	0%[a] (0/9)	81%[c] (88/109)	69%[bc] (73/106)	67%[bc] (14/21)	59%[b] (99/167)	<0.001
Mortality final treatment	1 (11%)	2 (2%)	8 (8%)	0 (0%)	15 (9%)	
Final treatment success where 2 or more applications (%)		87%[b] (39/45)	72%[ab] (52/72)	75%[ab] (3/4)	64%[a] (69/107)	0.039
Number of treatments – median (IQR)	1 (1 to 1)	1 (1 to 2)	2 (1 to 2)	1 (1 to 1)	3 (2 to 4)	
Complete cure following short duration of soak (15 minutes)	–	90% (36/40)	76% (26/34)	59% (10/17)	56% (32/57)	
Complete cure following long duration of soak (60 minutes)	–	79% (23/29)	62% (5/8)	None	64% (25/39)	

Values within a row sharing the same superscript letter are not significantly different

debridement was deemed complete, significantly more dogs (54%, 60/112) achieved clinical remission than dogs with partial/incomplete debridement (21%, 6/28) (P = 0.003). Of the 436 dogs, 145 (33%) did not undergo debridement. Their first treatment remission rate was 27% (39/145), which was significantly lower (P = 0.041) compared to the 37% (108/291) success rate in dogs that were debrided (Table 2).

Second treatments were undertaken in 63% (268/423) of cases, of which 72% (193/268) involved the same treatment approach (Table S2). All of the cases initially treated with oral antifungal monotherapy that received second treatments (5/5) changed group, as did 31% (29/93) of the RD group, 9% (9/103) of the TR group and 55% (6/11) of the SR group. A different approach was reported for 46% (26/56) of the mixed group. There were insufficient changes to determine reliably whether there had been a trend over time towards a preferred alternative treatment.

Final treatment outcome

Overall, in the final treatment outcome, 66% (274/412), 95% exact CI (62% to 71%) of dogs achieved complete clinical remission, 24% (98/412) partial clinical remission, 1% (3/412) no change, 3% (11/412) progressive disease and 6% (26/412) of dogs were euthanised. Up to nine treatments were undertaken (median 2 [IQR 1 to 3]) (Table 1). The median number of RD treatments was one (IQR 1 to 2). However, overall, multiple treatments were performed to achieve complete clinical remission in 63% of cases.

Some 13% (10/77) of cases progressed from a first RD treatment to subsequent TR procedures, but no cases progressed from RD to SR. There has been an increasing use of debridement over the past decade ($r_s = 0.629$, P = 0.028) and an increasing success rate of treating SNA in the UK ($r_s = 0.823$, P = 0.001) (Fig 2).

When debridement was deemed complete, 77% (86/111) of dogs achieved complete clinical remission compared to 52% (14/27) of dogs with partial/incomplete debridement (P = 0.015). The number of treatments required to achieve complete clinical remission was lower (median [IQR] 1 [1 to 2]) when complete debridement was achieved than not (median 2 [1 to 4.2]). The addition of a soak (without depot administration) in combination with debridement resulted in 68% (138/203) complete clinical remission; not significantly different from the 66% (47/71) without (P = 0.771). There was also no significant difference between complete clinical resolution with a shorter (15 minutes) soak duration (70%, 104/148) of cases compared to longer (60 minutes) soaks (70%, 53/76) (P = 1.000) (Table 2). However, fewer treatments were required to achieve complete clinical remission for short soaks (P < 0.001: median [IQR] 1 [1 to 2]) compared to longer soaks (2 [1 to 4]).

Clotrimazole solution was the most commonly used antifungal, accounting for 84% (274/326) of soaks and 91% (302/331) of depot. The remainder used enilconazole solution, except for 1% (3/326) soak cases reporting 'other' The highest success rates of complete clinical remission were observed in dogs from the RD group receiving both soak and depot azole topical therapy (49% after one treatment and 88%, after final treatment).

Characteristics that affected the likelihood of achieving complete clinical remission after final treatment were assessed across all treatment groups. Complete clinical remission was associated with a younger age (odds ratio 0.89, 95% CI 0.84 to 0.95, P < 0.001) and was achieved more frequently if performed in more recent years (odds ratio 1.10, 95% CI 1.03 to 1.17, P = 0.003); but there was no significant association with sex/neuter status (P = 0.521) or body weight of dogs (P = 0.257). These conclusions on age, sex/neuter, weight and year remained unchanged in an analysis incorporating treatment group. The median age for each initial treatment group was not significantly different between treatment groups (Kruskal–Wallis P = 0.057) (Table 1).

Adverse effects from treatment were reported in 24% (97/403) of dogs (Table 3). Dogs treated with oral therapy only developed moderately increased alanine transferase and alkaline

Table 2. Treatment modalities employed in managing SNA in dogs, with percentage complete remission/resolution in brackets. Please note that some percentages are based on very few dogs

	First treatment outcome		Final treatment outcome	
Oral therapy	15 (0%)		9 (0%)	
Total	15 (0%)		9 (0%)	
Rhinoscopic debridement (RD)				
Neither soak nor cream	17 (47%)		12 (83%)	
Soak	57 (28%)		36 (78%)	
Cream	31 (32%)		19 (68%)	
Both	59 (49%)		42 (88%)	
Total	164 (38%)		109 (81%)	
Trephination (TR)	All dogs	With debridement	All dogs	With debridement
Neither soak nor cream	0		0	
Soak	4 (25%)	0	1 (100%)	0
Cream	30 (27%)	10 (60%)	20 (65%)	9 (67%)
Both	107 (30%)	9 (11%)	85 (69%)	7 (29%)
Total	141 (29%)	19 (37%)	106 (69%)	16 (50%)
Sinusotomy/rhinotomy (SR)	All dogs	With debridement	All dogs	With debridement
Neither soak nor cream	0		0	
Soak	2 (0%)	2 (0%)	1 (100%)	1 (100%)
Cream	7 (71%)	6 (67%)	3 (100%)	2 (100%)
Both	20 (55%)	18 (56%)	17 (59%)	15 (60%)
Total	29 (55%)	26 (54%)	21 (67%)	18 (67%)
Mixed	All dogs	With debridement	All dogs	With debridement
Neither soak nor cream	3 (0%)	3 (0%)	14 (64%)	8 (50%)
Soak	7 (29%)	7 (29%)	28 (64%)	25 (68%)
Cream	7 (43%)	7 (43%)	28 (50%)	21 (57%)
Both	70 (31%)	65 (29%)	97 (60%)	77 (57%)
Total	87 (31%)	82 (29%)	167 (59%)	131 (59%)

FIG 2. Improvement in UK clinicians' success rate in treating SNA over the past decade (r_s = 0.839, P = 0.001). To improve the sample size, the years 2007/2009/2010 were combined as 2010 and 2021/2022 combined as 2021. Symbol size is related to sample size.

Table 3. Number of dogs experiencing complications after initial treatment. Oral antifungal medication; rhinoscopic debridement (RD); frontal sinus trephination (TR); sinusotomy and/or rhinotomy (SR)

	Seizures	Aspiration pneumonia	Subcutaneous emphysema	Death	Reverse sneezing	Increased ALT	Increased ALP	Dysphagia	Epistaxis	Gastrointestinal signs	Lethargy	Other	None observed
Oral	0	0	0	0	0	3	2	0	0	0	0	1	10
RD	0	5	2	0	2	2	2	3	2	5	5	6	130
TR	1	3	16	4	0	1	1	3	4	4	3	4	92
SR	1	0	7	0	2	0	0	0	0	0	0	1	19
Mixed	0	3	8	4	4	0	0	2	3	0	3	6	55

phosphatase activities in 21% (3/14) and 14% (2/14) of cases, respectively. Subcutaneous emphysema was reported in 25% (7/28) of dogs following SR, 13% (16/126) of cases after TR and in 10% (8/82) of dogs with mixed treatment. The most severe negative outcomes included seizures (one dog each after TR and SR) and death in 3% (4/126) of dogs treated with TR and 5% (4/82) of dogs treated with SR, but this may have been related to treatment failure rather than a direct adverse effect of treatment. Adverse effects were reported in 15% (23/153) of dogs in the RD group, compared to 27% to 33% in other treatment groups.

Five of 141 (4%) dogs in the TR group died, with their deaths attributed to the fungal disease (Table 1). The median (IQR) time to death of 64/436 (15%) dogs who died before the end of the study was 82 days (19 to 627). Six per cent (26/436) of dogs were euthanased or died due to failure of treatment or due to progressive clinical (neurological) signs (10 after a single treatment and 16 after multiple treatments). A log-rank test of differences in survival times for the four treatment groups was not significant ($P = 0.137$).

DISCUSSION

Rhinoscopic debridement and TR were the most commonly used treatment approaches in UK referral practice with similar first treatment clinical remission rates. The 34% (104/305) clinical remission rate after either a single RD or TR is higher than previously reported (Ballber et al., 2018) and increased when two or more treatments were performed. Comparing outcomes between studies is challenging due to the different criteria used to define clinical remission. Higher remission rates (50%) have been reported after a single treatment (Vedrine & Fribourg-Blanc, 2018) where remission was defined solely by the absence of observed fungal plaques. In contrast, Ballber et al. (2018) reported a lower remission rate, but additional negative fungal cultures and histopathology were required to confirm remission.

The inclusion of a substantial number of cases from various centres in this study enabled a comprehensive comparison of treatment approaches for SNA. Notably, these cases were drawn from 23 different referral centres, with a median of 11 cases per centre (range 3 to 61), often encompassing more than one treatment approach. In contrast, previous studies have reported outcomes for a single treatment method performed at a single centre. Increased familiarity with a technique can help clinicians overcome the challenges posed by the learning curve, leading to improved outcomes. However, even individual clinicians do not always rely on a single treatment method, as the approach must be adaptable based on factors such as disease location and severity. The involvement of multiple centres in this study may introduce variability in operator experience, potentially contributing to the lower initial success rates observed.

The final clinical remission rate of 81% after RD in this study aligns with prior research, where remission rates ranged from 80% to 100% (Ballber et al., 2018; Billen et al., 2009). The median number of RD treatments performed was also consistent with previous studies on rhinoscopy-assisted approaches (Ballber

et al., 2018; Billen et al., 2009; Vangrinsven et al., 2018; Vedrine & Fribourg-Blanc, 2018).

Differences in the intervals between treatments could influence outcomes. In this study, the median time between first and subsequent treatments was longer than in previous studies, potentially contributing to more established clinical disease at the time of recurrence.

In the current study, clinical remission rates were highest in dogs treated with a RD and topical antifungals administered as both a soak and cream. However, used individually (soak or cream), topical antifungals had a lower remission rate than when no topical treatment was used. This apparent paradox may be a reflection of selection bias. The benefit of topical antifungal treatment can still be questioned for dogs undergoing rhinoscopic debridement, mirroring previous research (Vangrinsven et al., 2018) which found no additional benefit from extending the soak duration from 15 to 60 minutes.

While fungal resistance to these therapies has not been reported in current veterinary literature, there remains a potential for resistance development, similar to antimicrobial resistance (AMR) in bacteria. Overuse or inappropriate application of topical antifungals in cases where their benefits are limited could inadvertently contribute to the emergence of resistant fungal strains.

In this study, TR demonstrated a lower clinical remission rate (Table 1) compared to earlier reports that described first treatment (46% to 85%) and final remission rates of 69% to 91% (Hazuchova et al., 2017; Mathews et al., 1998; Sharman et al., 2010). Variations in how treatment remission was assessed – such as through endoscopic examination, clinical re-examination or telephone follow-ups – may have influenced these results. Additional factors potentially affecting outcome include the extent of the disease, the thoroughness of debridement, the choice of adjunctive antifungal agents and how these were administered (Sharman et al., 2010).

First-time clinical remission rates were highest for dogs undergoing SR as the first treatment. This is likely due to the increased likelihood of achieving complete debridement of fungal plaques and affected tissue. This observation may indicate that debridement is more effectively achieved with the use of SR compared to other techniques. Debridement of sinus disease poses significant challenges when performed endoscopically; therefore, sinusotomy may offer a more thorough and consistently successful outcome, particularly if extensive time is not spent attempting to achieve adequate debridement through endoscopic methods. It is also possible that dogs selected for SR were chosen based on factors such as the extent and location of the disease, as well as clinician preference for this approach. Nevertheless, this finding is consistent with previous reports of success rates for SR ranging from 50% to 65% (Belda et al., 2018; Mathews et al., 1998; Pomrantz & Johnson, 2010).

Thorough debridement was associated with a higher likelihood of treatment success across all treatment groups in this study. This aligns with prior studies that have shown the thoroughness of debridement significantly influences clinical outcomes for dogs with SNA (Sharman et al., 2010; Sharman & Mansfield, 2012; Vangrinsven et al., 2018; Vedrine & Fribourg-Blanc, 2018). However, in the current study, the assessment of debridement completeness was limited by the study's retrospective design, relying on subjective retrospective evaluation from clinical records.

The challenges of achieving complete debridement are well-documented in the treatment of non-invasive fungal rhinosinusitis. In humans, similar conditions are often effectively managed with either endoscopic or surgical intervention alone (Reischies & Hoenigl, 2014). Evidence indicates that, if the condition is non-invasive – a factor frequently under-evaluated – complete debridement may reliably lead to a cure with a single procedure, provided the debridement is thorough. However, achieving complete debridement can be difficult due to factors such as excessive haemorrhage, anatomical complexity or the extent of disease involvement in all species. Repeated procedures may therefore be necessary to enhance outcomes and achieve clinical remission in dogs. The improved outcomes associated with surgical intervention underscore the importance of comprehensive debridement.

Interestingly, neither the use of combination treatments nor mixed treatment approaches was associated with higher first or final clinical remission rates compared to monotherapy. This may reflect the limited additional benefit from a second modality (e.g. placement of indwelling catheters). It may also be influenced by selection bias as dogs that warranted multiple treatments may have been more severely affected.

In this study, the response to oral antifungal agents alone was limited, which is not surprising given that previous studies have reported similar treatment outcomes with oral antifungals (Sharp et al., 1993; Sharp & Sullivan, 1989). Physical removal of fungal plaques has repeatedly been demonstrated to correlate with treatment success and oral treatment omits this step completely. Systemic antifungals are not recommended for the management of non-invasive fungal rhinosinusitis in people (Deutsch et al., 2019). Such treatment is also not recommended in dogs.

Overall, adverse effects were documented in 24% of cases across all treatment groups, with subcutaneous emphysema seen at the sites of TR and SR, consistent with previous reports showing rates of 0% to 7% for these complications (Belda et al., 2018; Mathews et al., 1998; Pomrantz & Johnson, 2010; Sissener et al., 2006). The most severe outcomes were noted in cases treated with TR, including death and seizures, but this could again be a feature of case selection. Lysis of the cribriform plate was previously found not to be a contraindication to topical administration of antifungal medication (Belda et al., 2018) although theoretically, exposure of antifungal agents to the brain could be problematic.

Limitations

Given the retrospective nature of the study, objective assessment of treatment outcomes was not feasible. Clinicians used six different outcome gradations based on clinical assessments. Evaluating the completeness of debridement was also subjective and residual plaques may have been overlooked, particularly in difficult or inaccessible locations or where there was significant haemorrhage. Treatment modalities may not be random but potentially selected as a function of case severity. Selection bias represents an unmeasured potential confounding factor. In this study, the

retrospective nature of data collection and absence of a validated scoring system meant that case severity was not measured, representing an important limitation.

Furthermore, when clinical remission was defined by follow-up rhinoscopy, assessment of sinus involvement would only be possible when significant turbinate destruction had occurred. Exclusive sinus involvement was rare and could not be effectively monitored through rhinoscopy. Ideally, determining disease cure should also involve negative culture and/or PCR results, with or without histopathology. However, a study by Prior et al. (2024) highlighted the limitations in the sensitivities of these tests. Implementing standardised scoring systems could help reduce variability and provide more comparable treatment outcomes. However, previous attempts to use standardised scoring systems based on imaging have produced contradictory results, highlighting the challenges of assessing treatment response in this population (Mathews et al., 1998; Saunders & van Bree, 2003). The question as to which approach results in the optimal outcome remains undetermined and may also conceivably differ from patient to patient.

Clinical records may have been incomplete, potentially leading to an underestimation of the frequency of adverse effects. Additionally, treatment success might be under (or over) estimated in this study, as some dogs with persistent nasal discharge could have been cleared of fungal infection but were classified as treatment failures due to ongoing nasal discharge, which might be attributed to other causes (Lobetti, 2009). The rate of relapse may have been underestimated as clinical signs are often attributed to chronic rhinitis related to altered nasal anatomy and owners often decline reinvestigation/treatment and clinical signs are probably a marker of disease status.

Conversely, dogs that were free of nasal discharge might still have had persistent fungal plaques, especially if follow-up rhinoscopy was not performed. A limitation of this study is the absence of repeat endoscopic assessment and adjunctive testing to confirm the presence of fungal disease in dogs with persistent clinical signs, making it difficult to clarify the relationship between clinical signs and disease status.

This study provides a comprehensive overview of treatment approaches for dogs with SNA from referral practices across the United Kingdom. TR and RD were used in 70% of cases, with both techniques being performed at similar frequencies and achieving similar rates of clinical remission. However, the observed rate of complete clinical remission was lower than in previous studies. Treatment selection should be guided by clinician expertise, the extent of the disease and equipment availability, given the lack of evidence for a single optimal approach. The data suggest that oral therapy is unlikely to be successful as monotherapy. Importantly, consistent with previous research, this study reaffirms that the degree of debridement is the primary determinant of treatment outcome, highlighting its crucial role in achieving successful results for dogs with SNA.

Author contributions

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Conflict of interest

None of the authors of this article has a financial or personal relationship with other people or organisations that could inappropriately influence or bias the content of the paper.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author (CP).

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Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Data S1.