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ORIGINAL ARTICLE

T-shape versus circular shape: a retrospective evaluation of intraoperative and postoperative complications in a cohort of 142 dogs undergoing TECA-LBO for end-stage otitis

F. Esposito*, M. Rossanese†, L. Ballarini‡, M. Cantatore‡, S. Vincenti §, R. Vallefuoco¶, G. Romanelli**, D. Murgia ††, S. Del Magno ‡‡, E. M. Morello§§ and F. Cinti ¶¶,1

*North Downs Specialist Referrals, Bletchingley, UK
†Royal Veterinary College, London, UK
‡Anderson Moores Veterinary Specialists, Winchester, UK
§Vetsuisse Faculty, University of Bern, Bern, Switzerland
¶Pride Veterinary Referrals, Derby, UK
**Ambulatorio Veterinario Oncopets, Milan, Italy
††Dick White Referrals, Six Mile Bottom, UK
‡‡Department of Veterinary Medical Sciences, University of Bologna, Ozzano dell'Emilia, Italy
§§Department of Veterinary Medical Sciences, University of Turin, Grugliasco, Italy
¶¶Ospedale Veterinario I Portoni Rossi-Anicura, Zola Predosa (BO), Italy

1Corresponding author email: filippocinti@icloud.com

Objectives: To report the impact of the surgical approach (T-shaped or circular incision) on intraoperative and postoperative complications associated with total ear canal ablation and lateral bulla osteotomy.

Materials and Methods: Medical records of dogs that underwent total ear canal ablation and lateral bulla osteotomy with T-shaped or circular incisions between 10 referral hospitals were retrospectively reviewed. Intraoperative and postoperative complications and follow-up were analysed and compared between groups using Fisher's exact test for categorical data and the Mann–Whitney rank-sum test for numerical data, with $P < 0.05$ considered significant.

Results: One hundred and forty-two dogs were included, totalling 156 surgeries: 84 were performed via circular incision (O-group) and 72 with a T-shaped incision (T-group). The groups were similar for sex ($P = 0.182$) and body weight ($P = 0.836$) distribution; the T-group was older at the time of surgery ($P = 0.019$).

Intraoperative bleeding occurred in 13/156 (8%) dogs and significantly more frequently in the O-group ($P = 0.03$; 11 O-group [7%], two T-group [1%]). Postoperative complication rate was 38.6% ($n = 60$): wound complications occurred in 31/156 (20%) dogs, more frequently in the T-group ($P \leq 0.001$; eight O-group [5%], 23 T-group [15%]); postoperative facial nerve neuropathy occurred in 31/156 (20%) dogs, and weakly associated with the O-group ($P = 0.045$; 22 O-group [14.1%], nine T-group [5.8%]).

Clinical Significance: Surgical preference may guide the choice between performing T-shaped or circular incisions during total ear canal ablation with lateral bulla osteotomy. Circular incisions were associated with a higher incidence of intraoperative haemorrhage and postoperative facial nerve neuropathy, while

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T-shaped incisions may increase the risk of wound complications. Most complications in both groups were minor or self-limiting.

Journal of Small Animal Practice (2026); **67**, 130–138
DOI: 10.1111/jsap.70030

Accepted: 26 August 2025; Published online: 15 September 2025

INTRODUCTION

The combination of total ear canal ablation (TECA) with lateral bulla osteotomy (LBO) currently represents the most effective treatment option for patients suffering from end-stage ear disease unresponsive to medical management (Sharp, 1990). The presence of proliferative epithelial hyperplasia secondary to chronic inflammation is reported to be the primary indication for surgery in 59% to 85% of the patients (Sharp, 1990). Other indications for TECA-LBO include congenital anomalies, proliferative growths, aural tympanokeratoma, severe facial or aural trauma, neoplasia and para-aural abscessation (Saridomichelakis et al., 2007).

Several complications have been reported in veterinary literature such as haemorrhage, nerve injuries, wound breakdown, chronic abscessation and fistulation, necrosis of the pinna, cosmetic alteration and infection (Coleman & Smeak, 2016; Smeak, 2011). Neurological signs associated with TECA-LBO include Horner's syndrome, vestibular signs and facial nerve paresis or paralysis. Of these, facial nerve neuropathy was the most frequently encountered complication in dogs, with reports ranging from 13% to 48.9%, though it was rarely permanent and infrequently required intensive medical intervention (Seward et al., 1958; Smeak, 2011; Spivack et al., 2013).

The surgical technique was originally described with a T-shaped incision, which outlines the external meatus and projects the incision over the vertical ear canal, immediately ventral to the tragus, allowing further access to the horizontal portion of the ear canal and osseous auditory meatus (Beckman et al., 1990; Smeak, 2011); however, many surgeons applied a modification of the technique consisting of a single circular incision outlining the auditory meatus, resulting in a smaller approach (Smeak, 2012).

In dogs with erect ears and in cats, the loss of cartilage support at the base of the pinna can lead to cosmetic alterations, such as the ear failing to stand. To mitigate the risk of developing a floppy-ear appearance, other techniques have been developed, such as the use of a single-pedicle advancement flap and an inverted UV-shaped incision been proposed. These approaches help preserve the structural integrity of the pinna and reduce the likelihood of ear collapse (McNabb & Flanders, 2004; van Venker- Haagen, 1983). A limited operating window with consequent poor visualisation was believed to be one of the leading causes associated with iatrogenic damage of the major neurovascular structures (Smeak, 2011; Smeak & Dehoff, 1986). Although the topic is frequently discussed among surgeons, there is a lack of evidence supporting a difference in complication rate or outcomes based on the surgical approach for TECA-LBO. A search was conducted on June 15, 2024, using the keywords "TECA-LBO", "dog ear surgery", "surgical approach TECA", "complication rate TECA", across Google Scholar and PubMed databases; no studies were identified that had compared the impact of incision shape on surgical complications.

The aim of this study was to evaluate whether performing a circular or a T-shaped incision would affect the incidence of intraoperative and postoperative complications associated with total ear canal ablation. These authors hypothesised that there was no difference in intraoperative or postoperative complications and outcome between the two types of incision.

MATERIALS AND METHODS

Study design and inclusion criteria

Medical records from 10 referral centres were retrospectively reviewed to identify canine patients who underwent TECA and LBO for end-stage otitis between March 2006 and February 2023.

Study design

This work involved the use of non-experimental animals only (owned or unowned) and followed recognised high standards of individual veterinary clinical patient care. Ethical approval from a committee was not therefore needed.

Inclusion and exclusion criteria

Dogs were included in the study if they underwent TECA-LBO surgery for the treatment of end-stage otitis media/externa. Bilateral single session TECA-LBO was classified as such if the two stages of the procedure were performed under the same anaesthetic event; these dogs were excluded from the study.

Dogs that underwent TECA-LBO with a comprehensive clinical record and an available description of the surgical approach and a follow-up period of at least 14 days were included in the study. The selected cases were divided into two groups according to the shape of the incision: T-group (T-shaped skin incision) and O-group (circular skin incision). Dogs were excluded from the study if the leading reason for performing TECA-LBO was revision surgery, a diagnosis of para-aural abscess or if the histopathological diagnosis was consistent with neoplastic disease. Dogs with preoperative clinical signs of facial nerve neuropathy, preoperative vestibular signs, incomplete medical records, or missing surgical reports were excluded.

Keywords used

Keywords used to retrieve cases were "Total ear canal ablation and lateral bulla osteotomy", "TECA-LBO", "end-stage otitis" and "ear surgery". If the search function was not available in the medical record system the investigator's case log was searched instead.

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Data extraction

Data collected included signalment (breed, gender, age and body weight), clinical presentation, diagnostic technique (CT, otoscopy, MRI), surgical technique, use of surgical drains, intraoperative and postoperative complications, culture and sensitivity results, histopathology reports and length of hospitalisation. The surgical records were examined for each dog. Bilateral staged procedures were classified as such if the diagnosis of bilateral disease occurred at the time of presentation, but left and right TECA-LBOs were performed separately within any time frame.

Prophylactic antibiotic therapy was selected independently in each centre and retrieved from the medical records. Intraoperative complications were defined as complications occurring between skin incision and closure and recorded in the medical records at the time of surgery. Follow-up was obtained by evaluating the medical records and was considered to be short-term follow-up if it was <30 days, medium term when between 30 days and 1 year and long-term if >1 year.

Postoperative complications were classified according to the Clavien-Dindo grading system: grade 1 included any deviation from a standard postoperative recovery that resolved with conservative measures or medical management, such as anti-inflammatory therapy. Grade 2 comprised complications requiring prolonged pharmacological treatment or blood transfusion. Grade 3 included complications necessitating surgical intervention or those with persistent clinical signs at long-term follow-up (>1 year). Grades 4 and 5 describe complications that lead to life-threatening complications and the death of the patient, respectively (Clavien et al., 2009). Onset, duration and severity of the complications were retrospectively extracted from the medical records.

Surgical technique

TECA-LBO procedures were performed according to previously described techniques (Beckman et al., 1990; Smeak, 2011, 2012; Smeak & Dehoff, 1986). In short, in the O-group, a circular incision through skin and cartilage was made over the external acoustic meatus, extending from just ventral to the tragus to the antihelix, cranially to the lateral crus of the helix and caudally to the medial process of the antitragus (Fig 1). In the T-group, this circular skin incision was combined with a vertical extension beginning at the level of the tragus and extending ventrally over the vertical ear canal (Fig 2).

In both groups, blunt dissection of the subcutaneous tissue and auricular muscles exposed the vertical ear canal, enabling careful dissection of peri-cartilaginous tissue along the horizontal canal to the rim of the bony external auditory meatus (Beckman et al., 1990; Smeak & Dehoff, 1986). Following amputation of the ear canal, a lateral bulla osteotomy was performed in all dogs with the aid of rongeurs or a high-speed burr (Mehrkens et al., 2021; Smeak, 2012), and a sample was then acquired for culture and sensitivity testing from the bulla following curettage and lavage with sterile saline.

Data reporting and statistic

Using the above-mentioned criteria, data were recorded using a spreadsheet (Microsoft Excel 365, Microsoft Corporation, Redmond, WA). Descriptive statistics were calculated between the O-group and the T-group in the period between surgery and the latest available follow-up (Microsoft Excel 365). All variables were tested to identify the association between the two groups and intraoperative and postoperative complications. Intraoperative complications included in this study for evaluation were restricted to iatrogenic damage to the facial nerve and inner ear, and inadvertent laceration of the maxillary artery and vein, retroglenoid vein, internal and external carotid arteries. Postoperative complications included the development of facial nerve neuropathy, vestibular signs, wound complications, cosmetic alterations, pinna necrosis and para-aural abscess. Categorical data were summarised as frequencies and percentages; significant associations were analysed using the exact Fisher test. Numerical variables were summarised with the median (and IQR); comparisons between two groups were performed with the Mann–Whitney rank-sum test for independent samples. All the analyses were performed using the open-source software R (R Studio), and a P value of less than 0.05 was considered statistically significant.

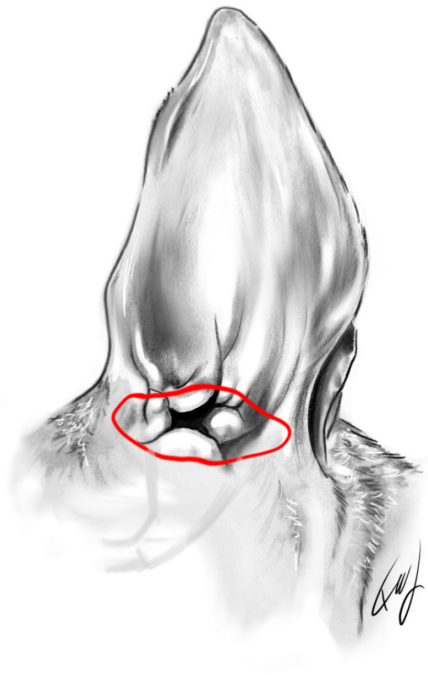

FIG 1. A circular incision (O-group) is made around the external acoustic meatus, starting just below the tragus and extending cranially to the helix and caudally to the antitragus.

RESULTS

Study population

Clinical records of 310 client-owned dogs were retrospectively reviewed. A total of 154 dogs were excluded for the following reasons: 35 due to a diagnosis of neoplasia, 27 because of incomplete medical records, 73 underwent a single-stage bilateral procedure, and 19 presented with preoperative facial nerve paralysis.

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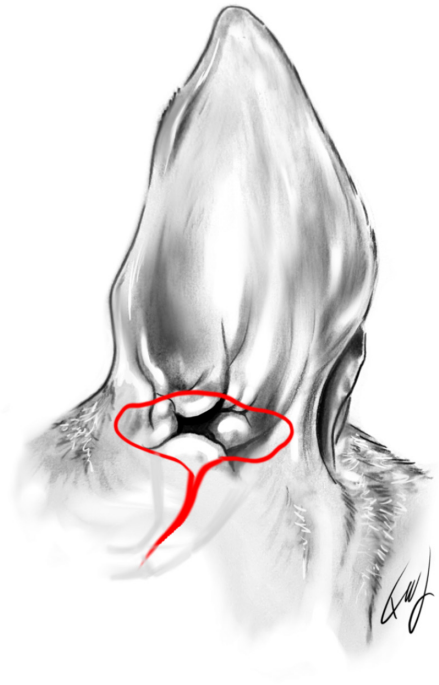

FIG 2. A T-shape incision (T-group) is made starting at the tragus, extending ventrally above the vertical ear canal.

One hundred and forty-two dogs met the inclusion criteria. Of these, 128 underwent unilateral TECA-LBO and 14 dogs underwent staged bilateral procedures. Each surgery was statistically evaluated singularly, accounting for a total of 156 TECA-LBO procedures (O-group 84/156; T-group 72/156). Crossbreed dogs represented 15% ($n = 23$) of the whole population, while the French bulldog was the most represented brachycephalic breed at 11% ($n = 17$). The remainder of the breeds represented in the study were grouped in Table 1.

A total of 26 dogs (17%), with even distribution between the two groups, were classified as extreme brachycephalic breeds according to the criteria previously established in other studies (Banks et al., 2023; O'Neill et al., 2015). The population of this study included 98/156 (63%) male (51 intact [33%] and 47 neutered [30%]) and 58/156 (37%) female dogs (17 intact [11%] and 41 neutered [26%]). Mean body weight was 22.5 kg (range 6 to 73). There was no difference in distribution between the two groups regarding sex ($P = 0.182$) or body weight ($P = 0.836$); the mean age at presentation varied between the two groups, with dogs in the T-group undergoing surgery at an older mean age of 7.9 years (range 2 to 16) compared to 6.4 years (range 1 to 13) in the O-group ($P = 0.019$). Short-term follow-up (median 18 days, range 14 to 30 days) was available for 142/156 (91%) dogs; medium-term follow-up (median 120 days, range 30 to 365 days) was available for 66/156 (42%) dogs, and long-term follow-up (median 812 days, range 367 to 2396 days) was available for 69/156 (44%) dogs. There was no significant difference in follow-up duration between the two groups.

Table 1. Breeds

Breeds	Number per breed
Crossbreed	23
French Bulldog	17
Labrador retriever; English cocker Spaniel; West Highland white terrier	12
German shepherd	7
English Bulldog; border terrier; Cavalier king Charles Spaniel	5
Pug; Golden retriever; American Staffordshire; Maremma shepherd dog; Saint Bernard	4
English Springer Spaniel; Italian spinone; Beagle	3
American cocker Spaniel; grifone vandeano	2
Boxer; Bull terrier; Dachshund; Segugio Italiano; Patterdale terrier; Yorkshire terrier; Shar Pei; Miniature schnauzer; Irish Setter; Shih-tzu; Pyrenean mountain dog; border collie; Dalmatian; flat coated retriever; lakeland terrier; Siberian husky; Staffordshire bull terrier; Tibetan terrier; Welsh terrier; Welsh corgi; chow chow; Cane Corso; fox terrier; German wire-haired pointer; bull mastiff	1

Preoperative clinical findings

An ECVS diplomate was the primary surgeon in 99/156 (63.5%) cases (O-group [67/156, 43%]; T-group [32/156, 20%]), being overrepresented in the O-group ($P \leq 0.001$), while in 57/156 (36.5%) cases surgery was performed by surgical residents under the direct supervision of an ECVS diplomate (O-group [17/156, 11%]; T-group [40/156, 26%]). Of the 156 dogs, eight (5%) presented with inability to fully open the mouth with no difference in distribution between the two groups ($P = 0.75$). CT scan was performed in a total of 102/142 (72%) dogs to investigate the clinical signs and paired with otoscopic evaluation in 28/142 (20%) and with MRI in one (0.7%) dog. MRI was performed in 17/142 (12%) dogs and completed with otoscopy in one (0.7%) dog. Surgery was performed in 37/142 (26%) dogs based solely on otoscopic evaluation, in cases where chronic disease and severe ear canal stenosis were present. The most common findings on CT scans included varying degrees of ear canal stenosis, dystrophic mineralisation of the ear canal and erosive changes in the bulla, with evidence of middle ear disease in the contralateral ear. On MRI, the most frequently observed findings were middle ear effusion suggestive of otitis media and features consistent with otitis interna. Of the 156 dogs. 18 (11.5%) were previously diagnosed with skin disease of different aetiology. Of the 156 cases, four (2.5%) were affected by a medically controlled endocrinopathy (diabetes [$n = 1$], Cushing's syndrome [$n = 1$] and hypothyroidism [$n = 2$]).

Intraoperative findings

Of the 156 procedures, 84 (54%) were performed with a circular incision (O-group) and 72 (46%) with a T-shape incision. Of the 156 dogs, 128 (82%) underwent unilateral TECA-LBO (O-group [80/156, 51%]; T-group [62/156, 40%]). The remainder 14/156 (9%) dogs (O-group [4/156, 2.5%]; T-group [10/156, 6.5%]) underwent staged bilateral procedures. Surgery

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Table 2. Incidence of intraoperative complications in relation to the shape of the incision

Intraoperative complications	Frequency	O-group	T-group	Grade I	Grade II	Grade III	P value
Intraoperative nerve damage	4 (2.6%)	2 (1.3%)	2 (1.3%)	-	-	4 (2.6%)	P=0.63
Intraoperative haemorrhage	13 (8.3%)	11 (7%)	2 (1.3%)	11 (7%)	-	2 (1.3%)	P=0.03

was performed on the right ear in 69/156 (44%) patients and on the left ear in 87/156 (56%) dogs with no difference in distribution within the groups. Each anaesthetic protocol was independently tailored by the anaesthetist in charge of the single case. Mean anaesthetic time was 168 minutes (range 90 to 320) (O-group 158 minutes [range 90 to 300 minutes]; T-group 191 minutes [range 95 to 320 minutes]), with the T-group associated with a longer anaesthetic time (P = 0.007). Prophylactic antibiosis was performed with cefuroxime in 95/156 (60.9%) dogs (O-group [66/156, 42.3%]; T-group [29/156, 18.6%]), cefazolin in 45/156 (28.8%) dogs (O-group [18/156, 11.5%]; T-group [27/156, 17.3%]) and potentiated amoxicillin in 16/156 (10.2%) dogs (O-group [3/156, 1.9%]; T-group [13/156, 8.3%]). Surgical time was 89 minutes (range 35 to 200) (O-group 79 minutes [range 35 to 175 minutes]; T-group 108 minutes [range 60 to 200 minutes]), where a longer surgical time was recorded in the T-group (P = <0.001).

Intraoperative complications occurred in 17/156 (11%) of dogs and more frequently in animals operated on with the circular incision (P = 0.04). The facial nerve was accidentally transected during the procedure in 4/156 (2.5%) dogs, two (1%) in the O-group and two (1.3%) in the T-group; this finding was not statistically significant (P = 0.63). Intraoperative bleeding was observed in 13/156 (8%) dogs, of which 11 (7%) in the O-group and two (1%) in the T-group, with a higher incidence among dogs in the O-group (P = 0.03). Intraoperative haemorrhages were observed in 11/156 (7%) dogs and classified as grade 1 complications (O-group [9/156, 6%]; T-group [2/156, 1%]); 2/156 (1.3%) dogs, both from the O-group, required blood transfusions and were classified as grade 2 complications. None of the dogs included in the study had surgical drains placed intraoperatively. Intraoperative complications are listed in Table 2.

Postoperative clinical findings and outcome

Postoperative complications were recorded in 60/156 dogs (38.6%), with a higher incidence observed in the T-group (36/156; 23.1%) compared to the O-group (30/156; 19.2%) (P = 0.016). Of the 156 dogs, 31 (20%) developed facial nerve neuropathy post-operatively, where 22/156 (14.1%) dogs belonged to the O-group and 9/156 (5.8%) to the T-group, with a statistically significant association between the shape of the incision and the development of facial nerve neuropathy (P = 0.049). Clinical signs resolved within the short-term follow-up period in the majority of dogs. Persistent clinical signs were documented in seven dogs, with follow-up available as long-term in four dogs and short-term in three dogs (median 365 days; range 14 to 487 days). Of the 156 dogs, five (3.2%), all from the O-group, developed vestibular signs post-operatively (P = 0.054); the clinical signs were recorded as mild, consisting of the sole head tilt and resolved at the latest follow-up in all dogs.

Wound complications occurred in 31/156 (20%) dogs, 8/156 (5%) of which belonged to the O-group and 23/156 (15%) to the T-group, with a positive association between the T-shaped incision and the onset of postoperative wound-related complications (P = <0.001). Of the 156 dogs, four (2.6%) (three in the T-group and one in the O-group) developed major wound dehiscence, and 1/156 (0.6%) dog in the T-group developed pinna necrosis requiring total pinnectomy; these cases were classified as grade 3 complications requiring revision surgery. The remaining complications included grade 1 events in 22/156 dogs (14.1%), consisting of self-limiting conditions such as seroma formation and partial wound dehiscence managed by secondary intention healing, and grade 2 complications in 4/156 dogs (2.6%) that required multiple courses of antibiotics due to persistent infection. Cosmetic alteration of the ear carriage was reported in 10/156 (6.4%) procedures, with four (2.6%) dogs in the O-group and six (3.9%) in the T-group, with no statistically significant difference between the two groups (P = 0.75). A diagnosis of para-aural abscess was recorded in 9/156 (5.8%) dogs, 5/156 (3.2%) in the O-group and 4/156 (2.6%) in the T-group (P = 0.61). For these nine dogs, medium and long-term follow-up was available in three and six dogs, respectively (median 495; range 150 to 1825 days). Postoperative complications in relation to the shape of the incision are listed in Tables 3 and 4.

Aftercare

The mean length of hospitalisation was 1.6 days (range 0 to 4) (O-group mean 1.6 days [range 1 to 4 days]; T-group mean 1.6 days [range 0 to 4 days]). Histopathological evaluation of the ear canal was requested in 103/156 (66%) dogs, revealing findings consistent with chronic otitis media and externa, mainly characterised by neutrophilic inflammation, along with squamous metaplasia and fibrosis. Culture and sensitivity test was performed in 112/156 (72%) of the procedures. Samples harvested prior to closure yielded a positive culture in 82/156 (53%) of the cases, while 30/156 (19%) samples were found negative for microbiological growth. Of the positive cultures, 62/156 (40%) isolated a single microorganism, while two or more microorganisms were found in 20/156 (13%) of the samples. *Staphylococcus* spp. were the most frequently encountered microorganisms, accounting for 41/156 (26%) of the positive cultures. The remainder of the isolated microorganisms were *Pseudomonas* 25/156 (16%), *Proteus* spp. 13/156 (8%), *Streptococcus* spp. 8/156 (5%), *Escherichia coli* 7/156 (4%); the population of microorganisms is detailed in Table 5.

Empirical antibiosis was started in 121/156 (77.6%) of the dogs (O-group [71/156, 45.5%]; T-group [50/156, 32%]). Postoperative antibiotic therapy was changed according to the culture and sensitivity results in 50/156 (9.6%) dogs (O-group [24/156, 15%]; T-group [26/156, 16.6%]) and consisted of the

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Table 3. Incidence of postoperative complications in relation to the shape of the incision

Postoperative complications	Frequency	O-group	T-group	Grade I	Grade II	Grade III	P value
Facial nerve neuropathy	31 (20%)	22 (14.1%)	9 (5.8%)	24 (15.4%)	-	7 (4.5%)	P=0.049
Vestibular signs	5 (3.2%)	5 (3.2%)	-	10 (6.4%)	-	-	P=0.054
Wound complications	31 (20%)	8 (5.1%)	23 (15%)	22 (14.1%)	4 (2.6%)	5 (3.2%)	P≤0.001
Para-aural abscess	9 (5.8%)	5 (3.2%)	4 (2.6%)	-	-	9 (5.8%)	P=0.61

use of a single antibiotic in 19/156 (12.2%) of the cases and in a combination of two antibiotics in 15/156 (9.6%) dogs (O-group [5/156, 3.2%]; T-group [10/156, 6.4%]). In 7/156 (4.5%) (O-group [3/156, 3.8%]; T-group [4/156, 2.5%]) dogs, the cultures showed a profile of antibiotic resistance. Potentiated amoxicillin was the most prescribed antibiotic where an oral course was started in 49% of the dogs (n=77/156), followed by cephalexin 26% (n=41/156), marbofloxacin 17% (n=26/156), enrofloxacin 2% (n=3/156), amikacin 2% (n=3/156) and doxycycline 0.6% (n=1/156). Antibiotic treatment was prescribed for a mean of 13 days (range 5 to 37). No statistical difference in infection rate or length of treatment was found between the two groups.

Table 4. Wound complications

Postoperative complication	Frequency	O-group	T-group	Severity
Pinna necrosis	1 (0.6%)	-	1	Grade 3
Major dehiscence	4 (2.6%)	1	3	Grade 3
Superficial infection	4 (2.6%)	1	3	Grade 2
Minor dehiscence	18 (11.5%)	5	13	Grade 1
Seroma formation	4 (2.6%)	1	3	Grade 1

Table 5. Isolated microorganisms

Species	Number	Percentage
Staphylococcus spp.	41	26%
Pseudomonas aeruginosa	25	16%
Proteus mirabilis	13	8%
Streptococcus spp.	8	5%
Escherichia coli	7	4%
Enterococcus spp.	3	2%
Corynebacterium	2	1%
Acinetobacter	1	0.6%

DISCUSSION

TECA-LBO has been considered a technically challenging procedure, requiring familiarity with the technique and a thorough understanding of the neurovascular structures surrounding the ear canal (Sharp, 1990; Smeak & Dehoff, 1986). Iatrogenic injury to these structures has been proposed to result from restricted surgical access and limited intraoperative visualisation, and some authors have hypothesised that a T-shaped incision may offer a wider surgical field and improved exposure of the ear canal, thereby reducing the risk of neurovascular injury (Smeak, 2011). However, other authors have suggested that various modifications of the technique can be performed with comparable success rates (Lanz & Wood, 2004; Smeak, 2012). Although frequently discussed among surgeons, the shape of the incision and its association with the incidence of surgical complications have not been evaluated yet, with surgeon preference driving the decision-making. In this study, we examined the complication rate associated with TECA when comparing two different surgical approaches, a circular *versus* a T-shaped incision. Our findings suggest that the shape of the surgical incision may play a role in the development of intraoperative and postoperative complications, with the O-group showing a higher incidence of intraoperative bleeding and postoperative facial nerve neuropathy, while the T-shaped incision may be linked to a higher occurrence of wound-related complications.

According to Smeak, intraoperative bleeding was a rarely reported complication occurring following accidental damage to the retroarticular vein, the external carotid artery, the maxillary vein or the internal carotid artery (Smeak, 2011). In our population, intraoperative bleeding occurred in 13/156 (8%) dogs, 11 (7%) in the O-group and two (1%) in the T-group, with a statistically significant association found between the O-group and the incidence of intraoperative bleeding. A possible explanation for these findings may lie in the increased reliance on retractors inherent to the circular incision, which often requires more extensive retraction to achieve sufficient exposure. This, in turn, could inadvertently distort normal anatomical landmarks, potentially leading to accidental vascular injury. Notably, all cases of major bleeding that required blood transfusion occurred in the O-group, suggesting that maintaining haemostasis may be more challenging with this approach, although other factors such as anatomical variation and differences in surgeon experience may also have contributed.

In our study, 31/156 (20%) dogs were affected by facial nerve neuropathy following TECA-LBO, with a higher risk of developing postoperative facial nerve neuropathy when using the circular incision. This finding was in line with the current literature where it was reported between 13% and 48.9% (Chan et al., 2020; Spivack et al., 2013), but despite its frequency, intraoperative factors affecting the incidence of facial nerve damage are yet to be found, and individual surgical techniques or patient-specific variables may play a significant role (Chan et al., 2020; Spivack et al., 2013). It is possible that a limited surgical approach necessitated more forceful use of retractor devices, which, combined with reduced visualisation, may have contributed to iatrogenic facial nerve injury through compression or imprecise tissue handling, likely resulting in neuropraxia, with a transient interruption of nerve function and conduction without reaching complete axonal degeneration. Spivack et al. (2013) reported that although facial nerve deficits occurred in 48.9% of dogs post-TECA-LBO, only 10.5% of these resulted in permanent clinical signs, with resolution taking up to 13 weeks in some cases; in the same study, a minimum follow-up period of 1 year was used to distinguish

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temporary from permanent deficits (Spivack et al., 2013). In our study, facial nerve deficits were still present in seven dogs at the latest follow-up. However, since only short-term follow-up was available for three of these dogs, it is possible that their deficits, although considered permanent at the time, may have resolved with a longer observation period.

Wound complications, including wound dehiscence, seroma formation and superficial infections, occurred in 31/156 (20%) dogs, with a higher incidence in the T-group. Most wound complications appeared to be minor and were managed either medically or conservatively with no impact on the final outcome. Revision surgery was required in five dogs and therefore classified as grade 3 complications, with no significant difference in distribution within the groups. The authors hypothesised that the T-shaped incision introduces a three-cornered defect at the junction of the vertical and horizontal limbs, that is intrinsically more prone to dehiscence, particularly if the skin edges are not perfectly apposed. Furthermore, the T-shaped approach necessitates a broader dissection of the subcutaneous tissues, potentially increasing the risk of seroma formation, wound breakdown or infection. In our study, 9/156 (5.8%) dogs developed para-aural abscesses within a median follow-up time of 495 days (range: 150 to 1825 days), similarly to what was previously described (Holt et al., 1996; Smeak, 2016). The development of para-aural abscess has been previously associated with several factors, including incomplete removal of the secretory epithelium lining from the tympanic bulla or osseous canal, osteomyelitis of the ossicles, retained infected ear canal cartilage, impaired drainage of the middle ear through the Eustachian tube, with the clinical signs typically occurring between 3 and 24 months following TECA-LBO surgery (Holt et al., 1996; Smeak, 2016; Spivack et al., 2013). For the population of this study, a long-term follow-up beyond 1 year was available in only 44% of cases, suggesting that para-aural abscesses may have been underreported; therefore, the true incidence of para-aural abscess formation in this cohort of dogs may have been higher than observed, highlighting the importance of extended postoperative monitoring in future studies.

The loss of support for the auricle following the ablation of the external auditory meatus is a significant concern for owners of dogs with erect ears. In our study, ten dogs developed an abnormal ear carriage, which appeared to be independent of the incision shape. However, due to the retrospective nature of this study, the severity of the cosmetic alteration in ear carriage could not be determined from the medical records. Several surgical techniques have been described in the literature to preserve ear carriage in dogs with erect ears, to include the inverted UV-shaped incision, first proposed by Venker-van Haagen (1983), in which a skin incision is performed from the intertragic incisure to the ventral limit of the vertical ear canal and from the tragohelicine incisure to the same ventral point. Closure is achieved by folding the caudal part of the pinna forward and performing routine reconstruction resulting in a more rigid base (van Venker-Haagen, 1983). Alternatively, a ventrally based single-pedicle advancement flap has been described in cats to relieve tension and help preserve ear carriage (McNabb & Flanders, 2004). While these techniques offer alternative approaches to ear canal ablation, a direct comparison with the more commonly employed T-shaped and circular incisions regarding the incidence of complications is not currently possible due to the limited published evidence on this topic. A positive association between the length of anaesthetic time and the incidence of postoperative complications was previously reported by Beal et al. (2000). In the current study, the T-group exhibited longer anaesthetic and surgical times, but this group also included a higher proportion of residents in training as primary surgeons. These findings may help explain the marginally higher rate of postoperative complications observed, possibly due to differences in surgical technique, tissue handling, and overall procedural efficiency associated with less experienced surgeons. Samples for culture and sensitivity testing were obtained following curettage and lavage of the bulla with sterile saline to ensure a representative sample (Beckman et al., 1990). Although the utility of culture at the bulla osteotomy site remains debated, its role in guiding postoperative antimicrobial therapy, particularly in patients with a history of chronic infections and prior antimicrobial use, is supported by existing evidence (Folk et al., 2022). Given the high likelihood of contamination at closure, empirical antibiotics were initiated perioperatively in most cases and adjusted based on culture results. Although definitive conclusions about efficacy cannot be drawn from this retrospective study, the findings suggest that timely and appropriate antimicrobial use may reduce postoperative complications, and prospective studies are warranted to guide standardised protocols. The authors of the present study restricted case selection on canine patients diagnosed with end-stage otitis as other indications for surgery, such as neoplasia, tympanokeratoma, severe ear trauma or congenital abnormalities were reported to have a higher incidence of short- and long-term complications (Coleman & Smeak, 2016; Hardie et al., 2008). These conditions were therefore excluded to provide a more reliable comparison of complication rates specific to the surgical approach. In the present study, statistical analysis revealed no significant differences between the two groups regarding sex and body weight distribution; however, it was noted that the T-group exhibited a greater average age when compared to the O-group. While age is recognised as a risk factor for the development of wound complications, the authors did not observe a statistically significant association between age and complication rates in this cohort. Therefore, although this age disparity is acknowledged, it is unlikely to have influenced the overall conclusions of the study.

In most of the dogs in this study (72%), CT study was the preferred imaging modality to investigate the ear disease; this preference is primarily due to the CT's ability to assess bony structures, such as detecting lysis of the tympanic bulla or petrosal temporal bone (Travetti et al., 2010). Whilst MRI is considered superior to CT for the evaluation of the soft tissue components such as the membranous labyrinth, cerebrospinal fluid and neural structures, allowing better differentiation between intra- and extracranial causes of cranial nerve deficits (Garosi et al., 2003), it is generally reserved for cases with neurological signs that require more in-depth investigation due to its limited availability, longer anaesthetic times and higher costs (Dvir et al., 2000). In 26% of dogs, video otoscopy was performed as the sole imaging modality, and in

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these instances, financial constraints may have influenced the decision to omit advanced imaging techniques such as CT or MRI. While limited imaging carries a theoretical risk of failing to identify concurrent pathology, such as neoplasia, a thorough review of the complete medical records and histopathological findings revealed no cases in which this omission adversely affected surgical planning, intraoperative findings or postoperative management. The main limitation of this study remained its multi-institutional retrospective nature; this led to a higher variability in case management and to the inclusion of a larger number of clinicians, with different levels of experience. Another important limitation of this study is the potential bias in the observed wound complication rate, which may be influenced by the fact that many dogs enrolled had likely received multiple courses of topical and/or systemic antibiotics prior to presentation. These previous treatments could have contributed to the development of multi-drug-resistant organisms or reduced the effectiveness of subsequent antibiotic therapy, thereby potentially impacting clinical outcomes. The first 14 days were identified by Smeak (2011) as the period with the highest incidence of postoperative complications, to include incisional complications, seroma formation, cellulitis and neurological signs, ranging between 8% and 31% (Smeak, 2011). Although patient recovery was monitored for a minimum of 14 days after surgery, and all patients therefore fell into our study period, late-onset complications and recurrence might not have been captured. This represents a limitation of the study, as it may underestimate the full spectrum of postoperative complications; however, given the established pattern of complication timing, we believe this limitation is relatively minor in the context of the primary outcomes of the study. In conclusion, performing TECA-LBO via a T-shaped incision, as originally described, appeared to be associated with a higher risk of wound complications, while the circular incision was linked to a greater incidence of intraoperative bleeding and postoperative facial nerve neuropathy. The findings of this study suggested that the incision shape may have influenced the development of intraoperative and postoperative complications, although most were minor and self-limiting.

Acknowledgements

The authors thank Laura Ventura for statistical and scientific support.

Author contributions

F. Esposito: Conceptualization (equal); data curation (lead); formal analysis (equal); supervision (equal); writing – original draft (lead). **M. Rossanese:** Data curation (equal); formal analysis (equal); investigation (equal); supervision (equal); writing – original draft (equal). **L. Ballarini:** Data curation (equal); formal analysis (equal); writing – original draft (equal). **M. Cantatore:** Data curation (equal); formal analysis (equal); writing – original draft (equal). **S. Vincenti:** Data curation (equal); formal analysis (equal); writing – original draft (equal). **R. Vallefuoco:** Data curation (equal); formal analysis (equal); writing – original draft (equal). **G. Romanelli:** Data curation (equal); formal analysis (equal); writing – original draft (equal). **D. Murgia:** Data curation (equal); formal analysis (equal); writing – original draft (equal). **S. Del Magno:** Data curation (equal); formal analysis (equal); writing – original draft (equal). **E. M. Morello:** Data curation (equal); formal analysis (equal); writing – original draft (equal). **F. Cinti:** Conceptualization (lead); data curation (equal); formal analysis (equal); methodology (equal); project administration (equal); supervision (lead); writing – original draft (equal).

Conflict of interest

The authors declare no conflicts of interest related to this report.

Funding information

The authors received no financial support for the research, authorship and/or publication of this article.

Data availability statement

The data are available from the corresponding author upon request.

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