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Comparison of Ear Tipping Techniques to Identify Sterilized Community Cats: A Randomized Controlled Trial

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Abstract

Introduction: Many methods are used for ear tipping, but the majority of practitioners have experience with only one. This study sought the most effective method of ear tipping, with the primary outcome being breakthrough bleeding, and secondary outcomes being immediate bleeding, duration, conformation to target length, cosmesis, client satisfaction, and tipper preference.

Methods: This randomized controlled trial, conducted between June 2022 and February 2023, enrolled cats at least 6 months old presented for Trap-Neuter-Return to one of seven techniques. Techniques were combinations of cutting tools, including Mayo scissors (MS), wood burning tool (WBT), and scalpel blade (SB), and hemostatic agents, including styptic gel (gel) and compounded hemostatic paste (CHP), and hemostat (H). Removal of 1 cm of the left ear pinna was timed, and breakthrough bleeding, the primary outcome measure, was blindly assessed. Client satisfaction was captured at discharge, 1 day, and 1 month, and cosmesis determined by three blinded independent raters.

Results: There were 252 cats from 80 unique colonies, with 36 per group, across 8 clinic days. The overall rate of breakthrough bleeding was 7% (95% confidence interval [CI]: 4–11%) and differed by technique ($P < 0.0001$). Neither WBT+H nor MS+H had any occurrences (95% CI: 0–10%), while SB+H/gel had the most (29%, 95% CI: 15–48%). The median time was 10 s (interquartile range [IQR] 7, 13). Tips were greater than target with WBT+H (33%, odds ratio [OR]: 3.8, $P < 0.0001$) as compared to SB+H. While SB+H had the highest mean cosmesis score (5.12/6, standard deviation [SD]: 0.87), WBT+H (4.4/6, SD 1.07) scored significantly lower ($P = 0.002$). Clients were satisfied with 88% (95% CI: 83–92%) of the ear tips at discharge (although response rate was insufficient for 24-hour and 1-month post), and there were no associations with technique. All 4 tippers preferred SB+H/CHP.

Conclusion: No technique was superior in all measures. While WBT+H and MS+H were superior by the primary outcome, SB+H/CHP was unanimously preferred by tippers.

Keywords: *community cats*; *trap-neuter-return*; *TNR*; *ear tipping*; *randomized controlled trial*; *stray cats*; *feral cats*; *feline medicine*

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Supplementary material
Supplementary material for this article can be accessed here.

Ear tipping is the practice of excising the distal pinna of cats to indicate that they have been sterilized.[1] While other identification methods have been employed, ear tipping remains the most effective[2] and is recommended by the Association of Shelter Veterinarians (ASV).[3] Ear tipping allows identification of sterilized cats from a distance (up to 20 m with binoculars),[4] enabling trappers to focus their efforts on populations or individuals that remain unsterilized and communicating to animal control officers and community residents that the population is being managed.[5,6] Individual cats benefit as they may be spared anesthesia and exploratory laparotomy if presented to a Trap-Neuter-Return (TNR) clinic.[7,8] Therefore, efficient creation of recognizable ear tips is important for the welfare of community cats.

Although ear tipping has been practiced since the 1950s,[9] there is no consensus on ear tipping methodology in the United States of America (US).[1] Approximately 0.5–1 cm is typically removed from the left ear, although some organizations will tip different ears to signify different sexes,[a] and different regions of the US will tip the right ear.[1] Straight

a. Community cat protocol: Ear tipping. Alley Cat Allies. https://www.alleycat.org/resources/feral-cat-protocol-eartipping Neighborhood cats | how to TNR | ear tipping. Neighborhood Cats. https://www.neighborhoodcats.org/how-to-tnr/veterinary/eartipping https://bestfriends.widen.net/s/qkqqfzn5tj/201270_ccphandbook_chapter14_jh

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hemostats, surgical scissors such as Mayo scissors, scalpel blades, and electrocautery may be used.[7] A nationwide survey regarding ear tipping methods reported concerns with bleeding (5%) and complications (1%), but did not find a statistically significant association of these complications with any particular method.[1] The most common complaint was too much ear tip was removed.[1] Most veterinary professionals report having experience with only one method,[1] and determining the optimal method of ear tipping is unlikely through their personal experience.

The goal of this randomized controlled study was to determine the best ear tipping method, as there are no ear tipping standards nor any prior studies that define the optimal ear tip outcome. Using the results from the previously mentioned survey, the optimal ear tip outcome was defined for this study as a quick, clean excision with complete hemostasis that was visually recognizable and cosmetically acceptable to clients. Breakthrough bleeding (bleeding after leaving the ear tip station) was chosen as the primary outcome measure because it was an issue for Midwestern University College of Veterinary Medicine's TNR clinic and was reported as a common concern among survey responders.[1] If breakthrough bleeding occurs, then this indicates that hemostasis was inadequate, and hemostasis is required for effective tissue healing.[10] Recognizing that this definition of the optimal outcome might depend on multiple factors, secondary measures of immediate bleeding (bleeding at ear tip station), duration of procedure, conformation to 1 cm target, cosmesis, client satisfaction, and tipper preference were included.

Methods

Animal and study design

This study was a randomized controlled trial approved by the Institutional Animal Care and Use Committee of Midwestern University IACUC protocol number: #AZ-4109. Sample size analysis determined that 35 cats were required per group to demonstrate a difference of 20% between proportions of a binary outcome ($\alpha = 0.05$, power = 0.8). This study is reported in accordance with the revised CONSORT statement.[11] Free-roaming cats presented to Midwestern University College of Veterinary Medicine's TNR events were enrolled in this study. Inclusion criteria included being at least 6 months old, healthy for surgery, and lack of ear tip. Exclusion criteria included having a left ear with abnormal appearance. Cats were enrolled and assigned to treatment group immediately after surgery in sequence from a randomly generated list of treatment groups generated via block randomization[b] by one of the researchers (EV).

b. Dallal, Jerry. "Randomization Plans: Never the Same Thing Twice!" Randomization Plans: Never the Same Thing Twice!, http://www.jerrydallal.com/random/random_block_size_r.htm

Techniques

Ear tipping techniques were chosen based on the frequency of use reported by respondents in a previous survey of ear tipping practices, cost, and availability and practicality to our clinic.[1] Cutting equipment included Mayo scissors (MS), #15 scalpel blade (SB), and 510°C wood burning tool with universal point tip (WBT).[c] Hemostatic agents included commercially available (Kwik Stop) styptic gel (gel) and compounded hemostatic paste (CHP). Some techniques used a hemostat (H). Combinations of cutting equipment, hemostatic agents and hemostat resulted in seven treatment groups: wood burning tool and hemostat (WBT+H), scalpel blade and hemostat with gel (SB+H/gel), scalpel blade and hemostat with compounded hemostatic paste (SB+H/CHP), Mayo scissors and hemostat with gel (MS+H/gel), Mayo scissors and hemostat with compounded hemostatic paste (MS+H/CHP), Mayo scissors with styptic gel (MS/gel), and Mayo scissors with compounded hemostatic paste (MS/CHP). For MS+H and SB+H, excisions were made above the hemostat, whereas for WBT+H, cuts were made below the hemostat. The scalpel blade from the sterilization surgery was used to perform the tip. The CHP was mixed each morning and consisted of 1300 g styptic powder (Kwik Stop), 1.2 mL lidocaine (2%), 1.2 mL Betadine solution, 0.4 mL 1:1000 epinephrine, and 5 g of water. Sterile water was periodically added to the CHP to maintain consistency. Both hemostatic agents were applied with a cotton tip applicator.

Pilot study

A three-day pilot was conducted to familiarize the researchers with the clinic flow, refine ear tipping methodology, and ensure that the researchers were proficient and consistent with the ear tipping techniques. Several CHP recipes reported by survey[1] were evaluated, with the one providing the most reliable hemostasis selected for the study.

Procedures

Anesthesia was induced via an intramuscular injection of TTDex (100 mg/mL telazol, 5 mg/mL butorphanol, and 0.25 mg/mL dexmedetomidine) through the trap at 0.02 mL/kg based on the cat's visually estimated weight.[12] After becoming unresponsive to stimulus, cats were examined, with age estimated based on dentition and secondary sex characteristics, and prepared for surgery. Sterilization was performed by veterinary students and veterinarians using High Quality High Volume techniques as previously described.[13] Researchers (RE, MS, EV, and AX) performed all ear tips at the ear tipping station after surgery. Cats were

c. Creative Woodburner® Value Tool (5570), Walnut Hollow, Conestoga PA, USA

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positioned in ventral recumbency (Fig. 1) with head propped on a rice-filled sock for both the tipping and photography.

The tip of the left ear was removed via the randomly assigned method, with a target of 1 cm based on the most common ear tip size reported in the survey.[1] For methods involving hemostats, hemostats were left on for the duration of cutting, and application of hemostatic agent immediately thereafter (left to dry in place with no removal), and once the visual confirmation of hemostasis was made, then hemostats were removed. After application of gel or CHP and any resolution of immediate bleeding (bleeding at ear tip station) with the same assigned hemostatic product was confirmed, the duration of the procedure was noted (equivalent to the time spent cutting and applying hemostatic product), and cats were photographed using the same camera (iPhone Xr) at a head-on angle and consistent distance of 30.5 cm for later cosmesis rating. Ear tips were measured against a 1 cm ear tracing to determine if the amount of tip removed was greater than, equal to, or less than the target. Cats were monitored for breakthrough bleeding for 15 min in the recovery room (a space shared by all cats presented for TNR) by volunteers blind to treatment group. Whenever breakthrough bleeding (bleeding after leaving the ear tip station) occurred, CHP was used to occlude bleeding.

A cosmesis rating scale (Supplementary 1) consisting of two items was constructed based on the most commonly reported desired ear tip description: a straight line perpendicular to the vertical axis of the ear.[1] The straightness rating was determined via visual assessment by three independent raters (RE, MS, AX), and deviation from 90° to the vertical axis of the ear (perpendicular) item was measured using image processing and analysis software (ImageJ). The mean of the straightness item from the three raters was summed with the perpendicular item to create the cosmesis score.

Fig. 1. Cat #252 placed in the appropriate position for cosmesis rating.

At discharge, transporters (clients who drove the cats from the clinic to the 24-hour recovery location, but were not necessarily the caretaker) were asked by the discharging student if they were satisfied (yes or no) with the ear tip for each cat, with additional space to leave commentary explaining why or why not. The record did not include whether the transporter was the caretaker. Caretakers who consented to follow-up were emailed a survey 24 hours and 1 month after surgery. For the 24-hour survey, caretakers were asked to perform a visual inspection of the ears before the cats' release and report if they were satisfied. For the 1-month surveys, caretakers performed a visual inspection of the ear from a distance. Copies of all three surveys are available in Supplementary 2 online.

Statistical methods

Cat demographic variables included colony, sex, estimated age, and weight. Procedure variables included date, time of day, dose of TTDex, surgery duration, treatment group, and ear tipper (anonymized). Additionally, the components of the treatment groups, cutting equipment, hemostatic method, and use of hemostats were separately examined to determine their contribution. Outcome variables included breakthrough bleeding (primary measure, based on reported complication frequency),[1] immediate bleeding, duration of ear tip procedure, conformation to target length, cosmesis score, and client satisfaction. Data analysis was performed using commercial software (Stata 18), and significance was set at $P < 0.05$. P-values for non-significant associations were reported in text when less than 0.2. Normal data were reported as mean and standard deviation (SD), while non-normal data were reported as median and interquartile range (IQR) expressed as quartile 1, quartile 3. Tests of skewness and kurtosis were used to determine the normality. Baseline data were compared across treatment groups using a Kruskal-Wallis test followed by a Dunn's test if significant for continuous, and Fisher's exact for binary data. Logistic regression was used to assess associations between patient data and binary outcome measures, while linear regression was used to assess associations for continuous outcome measures. Models were created using backwards selection and clinical plausibility and used robust standard errors when available. Multilevel mixed-effects logistic regression was used when a likelihood ratio test was positive for ear tipper, clinic date, or colony, and penalized maximum likelihood was used when a dependent variable had no events. Interrater agreement was measured using a kappa test. Missing data were excluded from analysis, with the denominator reflecting the total number of complete records considered.

Results

Between June 2022 and February 2023, across 8 clinics, 252 cats from 80 unique colonies were enrolled in the study, with 36 cats in each treatment group (Table 1). Some colonies were seen at multiple clinics, with 94 unique combinations of date and colony. Most (67) were seen on one date, but 12 were seen at 2 dates, and 1 was seen at 3 dates. There were 115 males and 137 females enrolled. The median estimated age was 24 months (IQR 12, 36), median weight was 3.21 kg (IQR 2.71, 3.80), and median surgery duration was 17 minutes (IQR 6, 35). The estimated age between groups differed ($P = 0.007$), with MS+H/gel and MS+H/CHP younger than the other treatment groups. Median TTDex dose for all cats was 0.03 mL/kg (IQR 0.02, 0.03, range 0.01–0.07). The MS+H/CHP group received more TTDex per kg than the other groups ($P = 0.007$). Ear tipper was noted on 249 of the 252 records, with 82 (33%), 48 (19%), 118 (47%), and 1 (<1%) ear tips being performed by tippers one through four, respectively.

Primary measure

Breakthrough bleeding

Breakthrough bleeding occurred in 7% (18/247; 95% confidence interval [CI]: 4–11%) of cats across treatment groups, and the rate was different ($P < 0.0001$) between groups (Table 2). WBT+H and MS+H/gel had 0 counts (0%) of breakthrough bleeding, while SB+H/gel had the most at 10/34 (29%). In multivariable regression (Table 3) following univariable regression (Supplementary 3), immediate bleeding (odds ratio [OR] 4.3; $P = 0.008$), age (OR 1.03; $P = 0.029$), and treatment group were associated with the risk of breakthrough bleeding, with all groups

Table 1. Patient demographics by treatment group reported as median (IQR), count (%) or count/denominator (%) if all denominators not 36

	WBT+H	SB+H/gel	SB+H/CHP	MS+H/gel	MS+H/CHP	MS/gel	MS/CHP	*P*
Demographics								
Weight (kg)	3.5 (2.7, 4.3)	3.2 (2.7, 3.6)	3.2 (2.6, 4.3)	3.2 (2.8, 3.7)	3.0 (2.5, 3.3)	3.5 (2.8, 3.7)	3.3 (2.9, 3.7)	0.162
Age (months)	30 (12, 42)	24 (12, 36)	24 (12, 48)	**12 (12, 24)**	**12 (12, 24)**	24 (18, 36)	24 (12, 42)	**0.007**
Surgery duration (min)	17 (8, 34)	16 (6, 33)	14 (7, 39)	30 (7, 46)	25 (5, 39)	8 (5, 31)	13 (5, 30)	0.314
TTDex Dose (mL/kg)	0.03 (0.02, 0.03)	0.02 (0.02, 0.03)	0.03 (0.02, 0.03)	0.03 (0.02, 0.03)	**0.03 (0.03, 0.03)**	0.02 (0.02, 0.03)	0.03 (0.02, 0.03)	**0.007**
Female	17 (47%)	17 (47%)	19 (53%)	24 (69%)	24 (69%)	17 (47%)	19 (53%)	0.351
Male								

Confidence interval (95%) provided for primary outcome variable in square brackets. *P*-value determined by Kruskal-Wallis (non-normal continuous data), ANOVA (normal continuous data), or Fisher's exact (binary data). Significant *P*-values and measures significant in Dunn's Test or logistic regression in bold.

Table 2. Outcome measures by treatment group reported as median (IQR), count (%) or count/denominator (%) if all denominators not 36 due to missing data

Outcomes	WBT+H	SB+H/gel	SB+H/CHP	MS+H/gel	MS+H/CHP	MS/gel	MS/CHP	*P*
Breakthrough bleeding	0/36 (0%) [0, 10]	10/34 (29%) [15, 47]	3/36 (8%) [2, 22]	0/36 (0%) [0, 10]	1/35 (3%) [0, 15]	2/34 (6%) [0, 20]	2/36 (6%) [1, 19]	***P* < 0.0001**
Immediate bleeding	0/36 (0%)	11/35 (31%)	10/36 (28%)	3/36 (8%)	1/36 (3%)	10/35 (29%)	5/36 (14%)	***P* < 0.0001**
Procedure time	6 (5, 8)	10 (8, 13)	10 (8, 15)	10 (8, 12)	8 (6, 10)	12 (8, 15)	11 (9, 14)	***P* < 0.0001**
Tip 1 cm	23 (64%)	24 (67%)	21 (58%)	23 (64%)	22 (61%)	21 (58%)	20 (56%)	0.972
Tip > 1 cm	12 (33%)	3 (8%)	6 (17%)	4 (11%)	6 (17%)	7 (19%)	13 (36%)	**0.024**
Tip < 1 cm	1 (3%)	8 (22%)	8 (22%)	9 (25%)	8 (22%)	8 (22%)	3 (8%)	**0.046**
Cosmesis	4.7 (4, 5.3)	5 (4.3, 5.8)	5.7 (4.7, 6)	5 (4.3, 6)	5 (4.3, 5.3)	5 (4.3, 5.3)	4.7 (4, 5.5)	**0.042**

Confidence interval (95%) provided for primary outcome variable in square brackets. *P*-value determined by Kruskal-Wallis (non-normal continuous data), ANOVA (normal continuous data), or Fisher's exact (binary data). Significant *P*-values and measures significant in Dunn's Test or logistic regression in bold.

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Table 3. Multivariable regression results for the primary outcome measure, breakthrough bleeding

Variable	OR	95% CI	P
Treatment group			
SB+H/gel		Referent	
SB+H/CHP	0.10	0.02 to 0.58	**0.010**
WBT+H	0.04	0.00 to 0.80	**0.035**
MS+H/gel	0.05	0.00 to 0.95	**0.046**
MS+H/CHP	0.16	0.02 to 1.07	0.059
MS/gel	0.14	0.03 to 0.66	**0.013**
MS/CHP	0.17	0.04 to 0.84	**0.029**
Age (months)	1.03	1.00 to 1.06	**0.029**
Immediate bleeding	4.29	1.46 to 12.59	**0.008**

Significant *P*-values in bold.

except MS+H/CHP having a lower risk than the referent, SB+H/gel. Neither date nor tipper had a positive likelihood ratio test, suggesting that there were not unmeasured confounders that varied by day and that there were no systematic differences by ear tipper. Time of day, both as an individual variable and interaction term with hemostatic method, was not significant, suggesting that performance did not degrade over time. In models that compared the components of the treatment groups, use of MS (OR 0.2; $P = 0.001$) to cut the ear reduced the risk, while WBT (OR 0.1; $P = 0.054$) was not different. Use of hemostats with MS was not significant, nor was CHP ($P = 0.156$) or WBT as compared to gel.

Secondary measures

Immediate bleeding

Immediate bleeding occurred in 16% (40/250; 95% CI: 12–21%) of cats across treatment groups, and there were significant differences ($P < 0.0001$) between groups (Table 2). WBT+H had 0 counts of immediate bleeding, while SB+H/gel had the most, with 11/36 (31%; 95% CI: 16–48%). In multivariable regression, WBT+H (OR 0.03; $P = 0.021$) and MS+H/CHP (OR 0.12; $P = 0.021$) both had less risk of immediate bleeding than the referent group SB+H/gel. Date had a significant likelihood ratio test ($P = 0.027$), although ear tipper did not, but penalized maximum likelihood logistic regression was used since WBT+H had 0 counts, and including date as a random effect did not change the results at the precision reported. This suggests that any unmeasured confounders did not have a clinically meaningful impact on immediate bleeding. Visual inspection of the proportion of ear tips with immediate bleeding by date did not reveal a pattern. Time of day, both as an individual variable and interaction term with hemostatic method, was not significant. Use of hemostats with MS (OR 0.2; $P = 0.011$) and use of WBT (OR 0.04; $P = 0.021$) or MS (OR 0.4; $P = 0.014$) to cut the ear resulted in decreased risk of immediate bleeding. Dose of TTDex was significant in the cutting tool model (OR 0.5; $P = 0.009$), with increasing doses of TTDex decreasing the risk of immediate bleeding.

Procedure duration

Median procedure duration (Table 2) across all treatment groups was 10 s (IQR 7, 13; range 3,30), and this was different across groups ($P < 0.0001$). WBT+H ($P < 0.0001$) and MS+H/CHP ($P = 0.006$) both took significantly less time than SB+H/gel, with absolute differences of 4 and 3 s, respectively.

Conformation to target

Sixty-one percent (154/252; 95% CI: 55-67%) of the ear tips met the target of 1 cm, and there were no differences between treatment groups. However, ear tips greater than 1 cm (20%; 51/252) and less than 1 cm (18%; 45/252) differed by treatment group, $P = 0.024$ and $P = 0.046$, respectively. No cat demographic variable was significant for predicting conformation to or deviation from the target. Because hemostatic agent does not affect the cut size, models used the combination of cutting implement and the presence of hemostat rather than treatment group. In mixed-effects logistic regression with ear tipper as random effect, only the use of hemostats with MS increased the risk that ears would be tipped less than 1 cm (OR 2.7; $P < 0.0001$). WBT (OR 3.8; $P < 0.0001$) was more likely to remove more than 1 cm.

Cosmesis

The median cosmesis rating for the 245 of 252 (97%) photos that were correctly angled for scoring was 5 (IQR 4.3, 5.7) out of a possible 6, and varied by treatment group (Table 2). As compared to SB+H/gel, WBT+H had a cosmesis rating predicted to be 0.7 points lower ($P = 0.002$) and MS/CHP was 0.4 points lower ($P = 0.046$). No cat demographic or procedure variable besides treatment group was a significant predictor of cosmesis score or a candidate for consideration in a multivariable model. When considering just cutting equipment, MS was predicted to be 0.3 points lower ($P = 0.012$), and WBT 0.8 points lower ($P < 0.0001$) than SB. For hemostatic method, CHP was not different from gel, and WBT 0.6 points lower ($P = 0.01$). The use of hemostats with MS did not affect the composite cosmesis rating. When considering the items of the cosmesis score separately (each item 3 points) as compared to SB, WBT was less likely to be perpendicular ($P = 0.009$), with a mean score 0.4 lower than SB, while MS was not different. Both WBT and MS scores were lower for straightness, with MS 0.3 points and WBT 0.4 points lower than SB, $P < 0.0001$

and $P = 0.001$, respectively. Use of a hemostat with MS was not significant for either item. The kappa value for straightness rating was 0.4 ($P < 0.0001$).

Client satisfaction

Of the 252 cats, 220 (87%) from 74 of 80 possible unique colonies had a client satisfaction rating at discharge, with 195 (89%) indicating they were satisfied and 25 (11%) indicating they were not satisfied (Table 4). Date and colony both had significant likelihood ratio tests, but colony was used for the random effect as the chi-squared value was higher, and using both levels resulted in a large number of small clusters that prevented models from converging. No variables were significantly associated with client satisfaction, including any cat demographic variable, treatment group, conformation to target length, and cosmesis score. The only variables with $P < 0.2$ were WBT+H (OR 0.1; $P = 0.077$) and tip greater than 1 cm (OR 0.2; $P = 0.063$), but neither were significant in a multivariable model containing treatment group and tip greater than 1 cm. All clients consented to follow-up. Satisfaction ratings were returned for 37 cats (15%) from 16 colonies at the 24-hour mark, with 12 (32%) indicating satisfaction and 25 (68%) indicating dissatisfaction. Twelve ear tips were rated satisfactory at both the discharge and 24-hour time points, nine were rated unsatisfactory at both, and ten were satisfied at discharge, but unsatisfied at the 24-hour mark. None were unsatisfied at discharge and satisfied at the 24-hour mark, and four 24-hour ratings did not have a corresponding discharge rating. All but one of the 16 responding colonies were either satisfied with all ear tips (7 colonies) or unsatisfied with all ear tips (8 colonies), with 10 of the 23 (43%) unsatisfactory ear tips from a single colony that had previously reported satisfaction with three of the ear tips.

Table 4. Client satisfaction as measured at discharge, 24 h, and 1 month

	Time period		
	Discharge	24 hour	1 month
n	227	37	22
Cat response rate	90%	15%	9%
Colonies	74	16	9
Colony response rate	93%	20%	11%
Median cats per colony	2 (IQR 1, 4)	2 (IQR 1, 2)	1 (IQR 1, 2)
Range cats per colony	1, 13	1, 10	1, 10
Satisfied	197 (87%)	12 (34%)	9 (41%)
Dissatisfied	30 (13%)	23 (66%)	13 (59%)
Mean of mean colony satisfaction	90%	47%	67%

Cat response rate was based on 252 possible cats, and colony response rate was based on 80 possible colonies. All but one colony at the 24-hour and 1-month time points reported either complete satisfaction or complete dissatisfaction.

One colony reported satisfaction with 1 and dissatisfaction with 1. For the 252 surveys emailed at the 1-month mark, 22 (9%) responses were received from nine colonies, with 9 (41%) reporting satisfaction and 13 (59%) reporting dissatisfaction. All colonies were either completely satisfied (6) or completely unsatisfied (3), with the same colony of 10 cats reporting dissatisfaction with all ear tips. Two colonies with a total of three cats changed their response from dissatisfied to satisfied between 24-hour and 1-month. Seventeen of the 1-month ratings had a complete set of 3 ratings, three had only the 1-month rating, one had a 24-hour and 1-month rating, and one had a discharge and 1-month rating. The most common reason for dissatisfaction at discharge, if provided, was that too much of the pinna was removed (19/30, 63%), with the other complaint being non-linear tip margin (5/30, 17%). Because of the size of the colonies and within-colony homogeneity, the 24-hour and 1-month time periods could not be analyzed via regression.

Tipper preference

All researchers performing ear tips independently reported a preference for SB+H/CHP. Tippers reported ease of use and ability to "cut through the ear quickly" as reasons why they preferred it, and the CHP was perceived to be easily applied to the ear.

Discussion

The goal of this randomized controlled trial of ear tipping methods was to identify the optimal method of a quick, clean excision with complete hemostasis that was visually recognizable and cosmetically acceptable to clients. No one method was found to fulfill all of these desired attributes. Each method has benefits and drawbacks regarding the outcome measures assessed in this study, and practitioners may choose one or another method according to their needs.

Breakthrough bleeding

MS+H/gel had no breakthrough bleeding, although using a hemostat did not appear to be a contributing factor. Scissors are reported to be more traumatic than scalpel blades since they are duller and may have reduced bleeding via crushing.[14] WBT+H also did not have breakthrough bleeding, with the cauterizing action found to be highly effective.

The estimated age of the cat was associated with breakthrough bleeding, with risk increasing as the cat's age increased. The reason for this increase was unclear, but could relate to the increase in systolic blood pressure as cats age.[15] Pinnae size and thickness may also increase with age, although we did not measure tissue thickness ourselves in these patients. A similar increase in risk was not observed with immediate bleeding, but blood pressure may be decreased under anesthesia,[16] and the risk of immediate bleeding was decreased with increasing dose of anesthetic drugs. Blood pressure was not monitored at these clinics. The presence of immediate bleeding also raised the risk of breakthrough bleeding, likely because immediate bleeding is an indicator of unstable hemostasis.

Secondary measures

Immediate bleeding

Immediate bleeding was more common (16%) than breakthrough bleeding (7%). Similar to breakthrough bleeding, WBT+H had no counts of immediate bleeding, and bleeding was most common in the SB+H/gel group. Use of hemostat was protective against immediate bleeding, unlike breakthrough bleeding, possibly because the benefit of the crush of the hemostat decreased over time after removal. Similar to breakthrough bleeding, use of MS decreased the risk.

Procedure duration

WBT+H was the fastest (6 s). However, even though it was statistically different, the absolute difference between techniques of only 3–4 s is not clinically meaningful. All techniques can be performed quickly after minimal practice.

Conformation to target length

More than 60% of ear tips were cut at 1 cm, and there was association between different treatment groups and deviation from the target. WBT+H was more likely to take off more than 1 cm, and MS+H was more likely to remove less than 1 cm. With the WBT, the cut was made below the hemostat, while the cut was made above the hemostat with SB and MS, which may account for the direction of the deviation.

Cosmesis

WBT+H and MS+CHP were both significantly less cosmetic than SB+H. Ear tips made with the WBT were both less straight and less likely to be perpendicular, while MS, regardless of the use of hemostat, was less likely to be straight. The WBT can cause crinkling of the ear, which may have affected the perception of straightness, and tippers reported difficulty with cutting parallel to the hemostat with MS.

Client satisfaction

Most caretakers or transporters (89%) indicated satisfaction at discharge. There was a very large drop off in response rates for both the 24-hour and 1-month surveys, and unlike the responses at discharge, respondents tended to be completely satisfied or completely dissatisfied with all tips. When dissatisfied, the most common reason was that the clients believed too much of the ear was removed. It is possible that caretakers who were dissatisfied were more likely to respond to the follow-up surveys. Given the lack of association between client satisfaction and the variables measured here, as well as the intra-colony homogeneity in later surveys, client satisfaction may be more related to client expectation than technique. Client education might improve satisfaction.

Tipper preference

All tippers independently reported a preference for SB+H/CHP. SB+H also achieved the highest mean cosmesis score, consistently producing straight lines and perpendicular angles, perhaps in part since tips could be modified by the tipper before hemostasis. Tippers noted that WBT caused an unpleasant odor, and an evacuation system to reduce smoke and odor would be a helpful addition.

Limitations

There are no prior studies, including the previous survey of ear tipping technique, that define an optimal outcome measure for evaluating ear tip methods, resulting in a large number of exploratory outcome measures. Some data points were missing from the study sheets, although this was generally less than 2% of data and there was no systematic bias. Discharge client satisfaction surveys were administered by veterinary students, resulting in a lack of consistency and missing data. Tips were measured as less than 1 cm, equal to 1 cm, and greater than 1 cm for data recording speed, but would have been more optimally recorded as a continuous measurement. Only cats aged 6 months and older were included in this study because of concerns that the 1 cm target would be proportionally too large as younger cats matured, and all ages were estimates.

Some ear tip methods, particularly WBT, were more challenging to learn and the pilot duration may not have been adequate to fully master the techniques. However, there was no discernible pattern to the proportion of events by date, as only one regression model (immediate bleeding) had a positive likelihood ratio test for date (besides client satisfaction because of the correlation of date with colony), and the random effect of date was not clinically significant. One tipper (EV) had prior experience with SB+H, but she only tipped one ear during study enrollment, while all other tips were performed by researchers who had no prior experience with any of the techniques chosen for the study. The consistency of the CHP was maintained by adding water as needed, and this was not recorded. However, there was no association of time of day with immediate or breakthrough bleeding.

Satisfaction after discharge could not be reliably analyzed for association with ear tip method. We anticipated caretakers to report any complications such as infection, ear curling, recurrent bleeding, among others, but since the response rate was much lower than expected for 24-hour and

1-month checkpoints, these complications may be underreported, and it is possible there are differences in these outcomes between treatment groups. The number of colonies versus the size of the colonies did not allow for statistical control of the high intra-colony correlation. The clients providing ratings at discharge were a mix of transporters and caretakers, resulting in the potential for different people providing ratings at discharge compared to the other time points and the client type was not reliably recorded.

Conclusion

Different ear tipping methods have different benefits and drawbacks. WBT+H was the best of the seven methods by the primary outcome measure, breakthrough bleeding, and secondary outcome measures of immediate bleeding and procedure time, but among the worst in the secondary outcome measures of cosmesis and tips greater than the target. SB+H yielded the greatest cosmesis, had among the lowest risk of tips greater than the target, and was the tool of choice by the researchers, but often resulted in ear tips less than the target and, when used with gel, had the greatest risk of breakthrough bleeding. Mayo scissors had the most variability in ear tip length, performing the worst in both tips greater (when used without hemostat) and less (when used with hemostat) than the target, but performed well on the basis of immediate and breakthrough bleeding when used with hemostat. Although no single best method was found, the results of this study can be used to guide clinic practices and determine which method best suits their specific concerns.

Supplemental Materials

The following files are available online:

Supplementary 1: Cosmesis rating scale
Supplementary 2: Surveys for discharge
Supplementary 3: Univariable analysis

Author credit statement

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