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Pain and adverse behavior in declawed cats

Nicole K Martell-Moran[1], Mauricio Solano[2] and Hugh GG Townsend[3]

Abstract

Objectives The aim of this study was to assess the impact of onychectomy (declawing) upon subsequent development of back pain and unwanted behavior in cohorts of treated and control cats housed in two different locations.

Methods This was a retrospective cohort study. In total, there was 137 declawed and 137 non-declawed cats, of which 176 were owned cats (88 declawed, 88 non-declawed) and 98 were shelter cats (49 declawed and 49 non-declawed). All cats were physically examined for signs of pain and barbering. The previous 2 years of medical history were reviewed for documented unwanted behavior such as inappropriate elimination and biting with minimal provocation and aggression. All declawed cats were radiographed for distal limb abnormalities, including P3 (third phalanx) bone fragments. The associations of declaw surgery with the outcomes of interest were examined using χ^2 analysis, two sample *t*-tests and manual, backwards, stepwise logistic regression.

Results Significant increases in the odds of back pain (odds ratio [OR] 2.9), periuria/perichezia (OR 7.2), biting (OR 4.5) and barbering (OR 3.06) occurred in declawed compared with control cats. Of the 137 declawed cats, 86 (63%) showed radiographic evidence of residual P3 fragments. The odds of back pain (OR 2.66), periuria/perichezia (OR 2.52) and aggression (OR 8.9) were significantly increased in declawed cats with retained P3 fragments compared with those declawed cats without. Optimal surgical technique, with removal of P3 in its entirety, was associated with fewer adverse outcomes and lower odds of these outcomes, but operated animals remained at increased odds of biting (OR 3.0) and undesirable habits of elimination (OR 4.0) compared with non-surgical controls.

Conclusions and relevance Declawing cats increases the risk of unwanted behaviors and may increase risk for developing back pain. Evidence of inadequate surgical technique was common in the study population. Among declawed cats, retained P3 fragments further increased the risk of developing back pain and adverse behaviors. The use of optimal surgical technique does not eliminate the risk of adverse behavior subsequent to onychectomy.

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Introduction

The onychectomy procedure (declawing) is performed across the USA and Canada to eliminate the possibility of property destruction and scratches. Medical indications for the procedure include removal of nail bed neoplasms and paronchia. Some believe that declawing will stop the spread of zoonotic diseases to immunocompromised cat owners.[1–3] To avoid disease transmission from scratches, the Centers for Disease Control and Prevention recommend flea prevention, keeping cats indoors, away from strays and avoiding rough play with cats. However, declawing is not a recommended part of their strategy.[4] The documented increased biting behavior of declawed cats can lead to more severe disease in people than cat scratches.[5] In one study of cat-inflicted wounds presented to an emergency room, none of the cat scratches resulted in infection, whereas 20% of bite puncture wounds became infected, with several requiring

[1]Feline Medical Center, Houston, TX, USA
[2]Cummings Veterinary Medical Center at Tufts University, North Grafton, MA, USA
[3]Department of Large Animal Clinical Sciences, Western College of Veterinary Medicine, University of Saskatchewan, Saskatoon, Saskatchewan, Canada

Corresponding author:
Nicole Martell-Moran DVM, MPH, Feline Medical Center, Houston, TX, USA
Email: nkmartell@live.com

hospitalization.[6] Cat-bite infection rates on hands can be as high as 30–50%.[7]

There are several surgical techniques reported for removing the claw, including scalpel and laser disarticulation of the distal phalanx and use of guillotine nail clippers to cut a portion of the distal phalanx, leaving the articular base with the deep digital flexor tendon attached.[8–10] There have been studies addressing postoperative morbidity in declawed cats related to the development of lameness, reluctance to ambulate, chewing at the digits, paw swelling, nail regrowth, postoperative bleeding, infection and persistent pain, among others.[5,8–13] The procedure remains a common practice in North America, although eight cities in California have banned the procedure from veterinary practice.[14]

Most veterinary associations do not recommend declaw surgery without first attempting to train the cat. The American Animal Hospital Association states that it is opposed to the procedure except as a last resort and if the cat's adoptability is in jeopardy.[15] The American Association of Feline Practitioners' declawing position statement conveys the AAFP's strong belief that it is the obligation of veterinarians to provide cat owners with alternatives to declawing; also stressing the importance of informed client consent and acknowledging the possibility of negative side effects to the cat.[16] The American Veterinary Medical Association (AVMA) opposes declawing wild and exotic cats for non-medical reasons,[17] but states that declawing domestic cats is warranted after training methods have failed.[18]

The AVMA position statement also states that leaving a segment of the distal phalanx with flexor tendon attached may be desirable, citing a study from 1979.[18] The AVMA's Literature Review on the Welfare Implications of Declawing of Domestic Cats, published in 2016, also states that veterinarians may choose to retain a part of the distal phalanx to improve function of the foot.[19] However, the standard of care in the past decade for performing an onychectomy, as determined by Diplomates of the American College of Veterinary Surgeons, is to disarticulate the distal phalanx from P2, to sever the deep digital flexor tendon and to remove the entire P3 (third phalanx).[1,20–23] Anatomically, the nail is a modified layer of the epidermis that encases the unguicular hood and unguicular process. It has two distinct portions: the cornified claw sheath, which surrounds the unguicular hood, and the horn, which encases the unguicular process. The nail grows from the root of the cornified claw sheath. If a portion of the articular base of P3 is left behind during a declaw, there will be no new nail growth as the articular base of P3 is not attached to the cornified claw sheath.[24] One study linked the presence of P3 bone remnants to claw regrowth,[8] but not to the amount of P3 remaining or to other pathological or behavioral findings such as back pain, biting or inappropriate elimination.

The long-term impact of declawing cats and the effect it may have on weightbearing adjustments, chronic pain and other musculoskeletal diseases is unknown. Pain identification and management in cats has evolved significantly over the past decade. Cats manifest pain in a wide variety of forms, including, but not limited to, inappropriate elimination, flinching, increased body tension, excessive licking or chewing of fur (barbering) and other abnormal behaviors.[25–27] Musculoskeletal pain is the most overlooked cause of pain in cats given that they instinctively attempt to hide it, leading to owners' and veterinarians' inability to identify it.[25,26] Studies in human amputee patients have shown various sequelae, including back pain.[28,29]

In a PubMed search in June 2016 using the keywords 'declaw or onychectomy', no studies incorporating a modern pain assessment tool, with or without controls and aimed at revealing the presence of pain in declawed cats years after onychectomy, were found. One study identified a lack of a sensitive pain assessment tool in published declaw studies reviewed.[30] There is also a lack of published research in declawed cats with respect to the prevalence of long-term disease, other than nail regrowth, associated with P3 bone remnants. This is an important consideration given that an estimated 25% of the US domestic cat population is declawed.[11]

The purposes of this study were: (1) to determine if there was an association between the surgical procedure of declawing a cat and biting behavior, aggression, inappropriate elimination, back pain and barbering; (2) to determine the prevalence of P3 fragments remaining after declaw surgery; and (3) to determine if P3 fragments were associated with back pain, increased biting behavior, aggression, inappropriate elimination or barbering compared with declawed cats without P3 fragments.

Materials and methods

Sample population

The study population was comprised of a convenience sample of two cohorts of animals: declawed and non-declawed cats. The animals were sourced from two locations: owned cats presented to a veterinary clinic and relinquished cats housed in an animal shelter. Declawed owned cats were selected in sequential order of appointments in the veterinary clinic, no matter what the presenting reason, including wellness or diagnostic examinations, grooming, dentistry or received for boarding. Non-declawed owned cats were also selected sequentially by appointment until all of the declawed cats were age matched by year. Declawed cats from the shelter were included sequentially during routine examinations after relinquishment. Non-declawed cats from the shelter were chosen in sequential order of cages in the building based on age, by year, to match the declawed cats already represented in the study. The cages within the shelter were not divided by illness, reason for relinquishment or temperament. All cats in this study were spayed or neutered. Quarantined, unsocialized, primarily outdoor or feral cats were not included.

Each cat was physically examined, its age recorded and the last 2 years of history were assessed with respect to the method of declaw, and the presence of the outcomes of interest. In addition, radiographs were taken of the declawed limbs. All physical examinations and medical record assessments were performed by one of the authors (NM). Inclusion of the shelter cats in this study was approved by the medical manager and chief operating officer. All protocols were executed under the internal guidelines set forth for the ethical use of animals by the shelter.

Radiographic evaluation

With the owner's verbal permission, a single lateral and occasionally a dorsopalmar digital radiograph of the declawed limbs was obtained. The animals were not sedated unless this was required for other reasons. In a minority of cases, all four limbs were included in a single projection. To achieve unimpeded views of the surgery site, a very slight supination of the manus at the level of the carpus or raising the end of the paw slightly away from the detector was performed.

The owners, clinic staff and shelter staff were aware that the radiographs were part of a study; however, they were not aware of the study hypothesis. All radiographs were examined by a diplomate of the American College of Veterinary Radiology (MS) who was aware of the study hypothesis but unaware of the history and physical findings for each cat radiographically examined. Both front and all four limb declawed cats were included in this study; however, any cats with a previous history of orthopedic trauma, such as fracture, were excluded. Each radiograph was assessed for presence of P3 bone, interdigital osteoarthritis and visible signs of remodeling of the second phalanx. Digital radiographs, taken in the medical digital format (DICOM), were converted into a lossy electronic image format (JPEG) and saved for evaluation by one of the authors (MS). All declawed digits were placed into one of four categories: (1) all of P3 removed; (2) <25% of the articular base of P3 remaining; (3) 25–50% of P3 remaining; or (4) only the distal end of the ungual process removed (Figure 1). All findings were recorded in a Microsoft Excel spreadsheet.

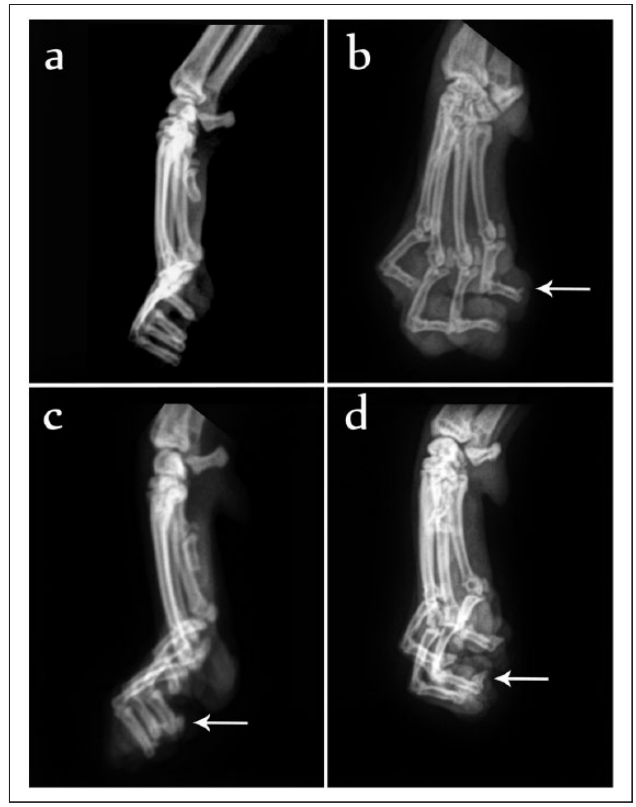

Figure 1 Four radiographic projections of the manus of four subjects in the study. The arrows indicate fragments left behind after onychectomy. The entire P3 has been removed in projection (a); <25% of the distal phalanx remains in (b); while >25% percent remains in (c); and only the tip of the distal phalanx has been removed (d)

Health and behavioral outcomes

Each cat was evaluated for pain using the 'signs of pain' table from the 2007 AAHA/AAFP Pain Management Guidelines for Dogs and Cats.[25] Palpation of the back was accomplished by applying moderate, even pressure with the thumb and middle finger over the transverse processes and musculature from the first thoracic vertebra to the first three caudal vertebrae. Cats showing a reaction such as flinching, exaggerated arching ventrally or tucking of the hips, hissing, or attempting to bite or flee during muscle and vertebral palpation were deemed painful only when loss of normal behavior or expression of abnormal behaviors could also be identified via the aforementioned guidelines. Those cats that reacted questionably to palpation were deemed non-painful. Those cats that reacted negatively to palpation but did not show loss of normal behavior or expression of abnormal behaviors were classified as non-painful. Any cat with known previous trauma (eg, fracture) or congenital or developmental condition (eg, hip dysplasia) was excluded from the study.

Biting history was determined through the presence of pre-existing alerts entered into the medical record by handling technicians or groomers indicating that the cat was prone to biting, a verbal warning in the examination room from the owner that the cat will bite or a recorded consultation with a veterinarian about biting behavior. Medical record alerts with regard to biting were added to the medical record by non-veterinary staff when touching, handling or light restraint (eg, petting, moving their position, lifting, and holding for nail trims or vaccinations) provoked attempts to bite.

A cat was listed as aggressive if a documented incident occurred during a veterinary visit or the owner reported unprovoked attacks by the cat when at home. Cats in a shelter setting were determined to be aggressive based on a history of attacking the owners, their children or shelter staff, or when a veterinarian documented that the cat had lunged at any person without provocation.

Inappropriate elimination behavior was determined by one or more episodes documented in the medical history in the previous 2 years, with or without a documented medical cause and included both periuria (inappropriate urination) and perichezia (inappropriate defecation). Inappropriate elimination in shelter cats was based on the listed reason for surrender being inappropriate elimination, or documented episodes of not using the litterbox while in a cage or free-roaming room. Cats with known urinary tract disease were not excluded from this study.

In this study, a cat was included in the barbering category when there was no evidence of a primary skin condition causing the hair loss and the behavior. Not all barbering cats were subjected to a full range of diagnostic procedures to rule out primary skin disease (ie, skin scrapings, food trials, blood tests). However, all cats included in the study were required to be current on topical monthly veterinary-obtained flea prevention. Any cat with visible evidence of fleas, a primary skin condition or potential for secondary endocrine cause (ie, hyperthyroidism) was excluded from the study.

Statistical methods

The two cohorts in the primary study were assembled after the outcomes of interest had occurred and therefore this was classified and analyzed as a retrospective cohort study. The cats were sourced from two locations, owned cats admitted to a veterinary practice and relinquished animals in an animal shelter. During the design phase of the study, age was assumed to be an important confounder in the relationship between onychectomy and the outcomes of interest. Therefore, at both locations, declawed cats and their controls were matched by year of age. The data related to all animals in the two cohorts were analyzed using χ^2 analysis and logistic regression (Statistix version 10). Initially, the univariate association of declaw surgery and animal location with each of the outcomes of interest (back pain, periuria/perichezia, biting, aggression and barbering) was assessed using χ^2 analysis. Subsequently, the combined association of declaw surgery and location, along with their interaction term (declaw surgery*location), was assessed using manual, backwards, stepwise, logistic regression. With this approach, each model was developed by starting with all three variables in the model and then manually removing them from the model based on the magnitude of their P values (highest P values removed first). Variables with P values <0.05 were considered significant and retained in the final models. In those instances where both declaw status and animal location were associated with one of the outcomes, confounding was deemed to be present if there was a 10% difference between the crude and adjusted odds ratios (ORs).

Primary analysis of the study data suggested that retention of P3 fragments in declawed cats may have had an impact upon the occurrence of adverse outcomes and that optimal surgical technique could be associated with fewer adverse outcomes. As a consequence, further analysis of the study data related to all 274 cats was undertaken by first assigning all study animals to one of three mutually exclusive cohorts – not declawed; declaw surgery leaving no P3 fragments; and declaw surgery resulting in retained P3 fragments – and then subsequently comparing the odds of adverse outcomes among the cohorts. Indicator variables were created for the three surgical outcomes so that declawed cats with and without P3 fragments could be compared with their nonsurgical controls. The combined association of surgical status and animal location with each of the outcomes of interest was then assessed using manual, backwards, stepwise, logistic regression. Initially, both indicator variables for the declawed animals, along with their location, were entered into the models and then manually backed out based on the magnitude of their P values. Both indicator variables were retained in the final models if either attained a P value of <0.05. Similarly, animal location was retained in the final model when the P value was <0.05. Potential confounding and interaction were assessed as described above.

In order to determine if declawed cats with retained P3 fragments were at greater risk of experiencing adverse outcomes than those having the entire P3 excised, a secondary analysis that included only the 137 declawed cats was performed. As with the previous analyses, the potential effect of surgical status and animal location was assessed using manual, backwards, stepwise, logistic regression. Age was also included as a potential risk factor in this analysis. Variables were retained in the final models when their P value was <0.05. Confounding and interaction were assessed.

Results

Among the 274 cats in the study, 137 had been declawed and 137 had not. There were 88 declawed and 88 non-declawed owned cats, examined at a veterinary clinic, and 49 declawed and 49 non-declawed cats examined in a shelter setting. The mean $\pm$ SD age of the cats was 8.0 $\pm$ 4.1 years (range 1–17 years).

Table 1 Summary of clinical outcomes in 274 declawed and non-declawed cats located at two different sites

		Shelter		Home	
		Declawed (n = 49)	Control (n = 49)	Declawed (n = 88)	Control (n = 88)
Back pain	Yes	22	7	17	10
	No	27	42	71	78
Periuria/perichezia	Yes	25	5	31	7
	No	24	44	57	81
Biting	Yes	13	1	20	8
	No	36	48	68	80
Aggression	Yes	3	1	11	4
	No	46	48	77	84
Barbering	Yes	8	3	6	2
	No	41	46	82	86

Table 2 Multivariate models of factors significantly associated with back pain and adverse behavior in 274 declawed and non-declawed cats

	Factor	OR	95% CI	*P* value
Back pain	Declawed	2.90	1.53–5.48	0.001
	Location	2.41	1.31–4.44	0.005
Periuria/perichezia	Declawed	7.20	3.64–14.26	<0.001
Biting	Declawed	4.51	2.07–9.84	<0.001
Aggression	Declawed	3.00	1.05–8.59	0.04
Barbering	Declawed	3.06	1.06–8.80	0.04
	Location	2.07	1.04–7.03	0.04

OR = odds ratio; CI = confidence interval

Radiographic assessment

Raising the end of the paw slightly away from the detector was more effective than the supination method in eliminating superimposition of the digits (Figure 1). Dorsopalmar or dorsoplantar views were of little value, as the normal flexed position of the second phalanx placed it at a 90º angle in relation to the detector and this often obscured the surgery site.

Among the 137 declawed cats, 86 (63%) showed radiographic evidence of residual P3 fragments. Of these, 31 (36%) had P3 fragments measuring <25% of the bones, 29 (34%) had fragments equivalent in size to 25–50% of the P3, and 26 (30%) showed evidence of having had only the ungual process removed. Four cats with externally visible nail regrowth had only the distal end of the ungual process removed when declawed. Thirty-three of the 137 (24%) cats were declawed on all four limbs. Although the technique used for all cats was unknown and could not be assessed statistically, all three methods (scalpel blade, guillotine and laser) were represented in the cats with retained P3 fragments (data not shown). Eleven cats also had radiographic evidence of P2 bone remodeling.

Health and behavioral outcomes

A summary of the data relative to the two age-matched cohorts, declawed and non-declawed cats, is presented in Table 1 and the final multivariate models developed during the primary analysis of the data are presented in Table 2. This analysis included all 274 animals in the study and shows that subsequent to onychectomy, the odds of back pain (OR 2.90), periuria/perichezia (OR 7.20), biting (OR 4.51), aggression (OR 3.00) and barbering (OR 3.06) were significantly increased in the 137 declawed cats as compared with their 137 non-declawed controls. In addition, there was a combined but independent association of being located at the shelter with both back pain (OR 2.41) and barbering (OR 2.70). No evidence of confounding or interaction was detected.

The results of the analysis of the data related to all 274 animals that was aimed at determining the impact of retained P3 fragments upon the occurrence of adverse outcomes are summarized in Table 3. Comparison of the two declaw cohorts (86 declawed cats with fragments and 51 without) with their 137 non-declawed controls showed that those with retained P3 fragments were at greater odds of back pain (OR 3.9), inappropriate elimination (OR 9.9), biting (OR 5.5), aggression (OR 4.7) and/

Table 3 Multivariate models of the association of P3 fragment retention with the occurrence of back pain and adverse behavior in 274 declawed and non-declawed cats

	Factor	OR	95% CI	*P* value
Back pain	Not declawed	Referent		
	P3 fragments: no	1.54	0.63–3.75	0.34
	P3 fragments: yes	3.94	1.99–7.84	<0.001
	Location	2.45	1.32–4.56	0.005
Periuria/perichezia	Not declawed	Referent		
	P3 fragments: no	3.94	1.68–9.26	0.002
	P3 fragments: yes	9.94	4.80–20.58	<0.001
Biting	Not declawed	Referent		
	P3 fragments: no	3.05	1.14–8.17	0.03
	P3 fragments: yes	5.51	2.42–12.54	<0.001
Aggression	Not declawed	Referent		
	P3 fragments: no	0.53	0.06–4.56	0.56
	P3 fragments: yes	4.7	1.61–13.71	0.005
Barbering	Not declawed	Referent		
	P3 fragments: no	1.67	0.38–7.31	0.5
	P3 fragments: yes	3.95	1.31–11.92	0.015
	Location	2.72	1.04–7.10	0.04

OR = odds ratio; CI = confidence interval

or barbering (OR 4.0), whereas declawed cats without P3 fragments were only at increased odds of biting (OR 3.1) and inappropriate habits of elimination (OR 3.9).

A summary of the data related to the impact of retained P3 fragments in the 137 declawed cats is presented in Table 4, and the final multivariate models are presented in Table 5. This secondary analysis revealed an increase in the combined odds of back pain (OR 2.7) and location in the animal shelter (OR 3.6) among declawed cats with P3 fragments compared with those without. Also, declawed cats with P3 fragments were at increased odds of demonstrating periuria/perichezia (OR 2.5) and aggression (OR 8.9) compared with those without retained P3 fragments. The age of the animal was not related to any of the outcomes ($P > 0.4$). Neither confounding nor significant interaction were detected in this analysis

Discussion

Although illegal in most other developed countries, declawing is a common practice in Canada and the USA. There is little published information regarding the long-term health effects of declawing in the cat. The current study shows a clear association between declawing and the presence of deleterious side effects after the typical postoperative period in a comparatively large sample population.

The primary analysis of the cohort data comparing declawed cats and a non-declawed control group shows that the odds of the highly undesirable habits of elimination, periuria and/or perichezia were much greater in declawed cats than their controls. In addition, declaw surgery was associated with a significant increase in the odds of back pain, biting, aggression and barbering. Although the causal relationship between declaw surgery and adverse outcomes has not been determined, plausible explanations do exist. Many cats express pain with a behavioral change such as biting, aggression or inappropriate elimination.[25] Clinically, we have observed that pain arising from the lower back is associated with inappropriate elimination. Similarly, if the source of pain is declawed phalanges, the act of walking on or digging in a gravel-type substrate may result in pain and aversion to use of the litter box. Many cats that eliminate outside of the litter box choose a soft substrate such as carpet, clothing or a location next to the litter box like a mat. With respect to aggression, following claw removal, a cat's only defense when upset or fearful is biting. When touched, a painful, fearful or stressed declawed cat may react by attempting to bite as it has few or no claws to scratch with. During the physical examination of the cats in this study, many biting attempts occurred when cats were lifted, creating an arched back; when they were touched or petted caudal to the middle thoracic vertebrae; or in anticipation of pain when a handler was reaching to touch the lower back or tail.

The removal of a cat's distal phalanges forces it to bear weight on the soft cartilaginous ends of the middle phalanges (P2) that were previously encapsulated within joint spaces. In this study, 11 declawed cats showed radiographic evidence of remodeling of the P2 bone. The significance of bone remodeling is unknown and was not explored in this study. There is currently no study that addresses the anatomic and pathologic changes affecting the P2 bone and cartilage that may incur over the declawed cat's lifetime. The potential for effects on the rest of the musculoskeletal system such as weightbearing among

Table 4 Summary of clinical outcome in 137 declawed cats at two locations

		Shelter		Home	
		P3 fragments (n = 31)	No P3 fragments (n = 18)	P3 fragments (n = 55)	No P3 fragments (n = 33)
Back pain	Yes	16	6	14	3
	No	15	12	41	30
Periuria/perichezia	Yes	18	7	24	7
	No	13	11	31	26
Biting	Yes	9	4	15	5
	No	22	14	40	28
Aggression	Yes	3	0	10	1
	No	28	18	45	32
Barbering	Yes	8	0	3	3
	No	23	18	52	30

other joints, arthritic changes, chronic pain elsewhere in the body or changes in bone density needs focused research. Based on the present study, a minority of cats showed remodeling of the middle phalanx. It remains unknown if the P2 remodeling was the result of damage to P2 during surgery or a mechanical pathophysiological sequela of P3 removal. Subjectively, none of the cats exhibited osteopenia and only one showed degenerative joint disease of an interphalangeal joint. However, radiographic changes in the cat do not always correlate with clinical signs. Full radiographic evaluation of more proximal joints was not included in this study.

The presence of P3 fragments in 63% of declawed cats is excessive and surprising. It reflects the use of poor or inappropriate surgical techniques, leading to increased odds of adverse outcomes in declawed cats. The primary analysis of the data related to all 274 cats in the study shows that declawed cats with P3 fragment retention are at greater odds of experiencing biting and inappropriate habits of elimination as compared with declawed cats without P3 fragment retention. To further explore the impact of P3 retention, a secondary analysis, limited to the 137 declawed cats, showed that cats with retained P3 fragments were at increased odds of back pain, periuria and/or perichezia and aggressive behavior when compared with declawed cats without fragments.

Table 5 Multivariate models of factors significantly associated with back pain and adverse behavior in 137 declawed cats with and without P3 fragments

	Factor	OR	95% CI	*P* value
Back pain	P3 fragments	2.66	1.1–6.41	0.03
	Location	3.56	1.6–7.86	0.002
Periuria/ perichezia	P3 fragments	2.52	1.2–5.32	0.02
Aggression	P3 fragments	8.9	1.15–69.13	0.03

OR = odds ratio; CI = confidence interval

The high incidence of P3 fragment retention detected in this study and its impact on long-term, adverse surgical outcomes, including back pain, were important findings and were related to performing digital radiography and standardized pain assessments on study cats. Discussions with animal owners during this study suggest that P3 fragment detection without the aid of radiographs is rare, even when claw regrowth occurs. The owners of all four cats with claw regrowth were unaware that new externally visible nail growth was present. Only one of all 137 declawed cats in this study was initially examined owing to an owner's concern that their cat showed signs of pain (eg, attempted to bite when petted caudal to the cervical vertebrae and reluctant to jump).

P3 fragment retention following declaw surgery may be the result of a variety of deficiencies in surgical technique. When using a blade, there are several portions of P3 that could be inadvertently left behind. The articular facet of the articular base of the distal interphalangeal joint is softer than the rest of the P3 and could easily be incised with a sharp scalpel blade, especially in kittens. The same is true for the flexor tubercle of the articular base of P3. When the claw is being retracted to cut the P3 away from the paw pad, the tubercle could be accidentally incised and left behind. If the entire portion of the articular facet is left behind, there is potential for a portion of the root of the cornified claw sheet to remain and for nail regrowth to occur.

Observational studies are subject to a variety of biases that should be addressed during the design, execution, analysis and interpretation of the research. Of particular concern in this retrospective study are the potential biases related to lack of blinding, diagnostic suspicion bias, and potential bias related to uncertainty of the time sequence of risk factors and the outcomes of interest. Wherever practical during the design and conduct of this study, attempts were made, through blinding of the investigators and control of confounding, to remove bias from the study. At the time of the interpretation of the radiographs, the radiologist was unaware of the clinical signs or behaviors exhibited by the animals. Owners, shelter and clinic staff were not informed regarding the study hypothesis or the outcomes of interest. During the clinical examination of the animals, the 'signs of pain' table from the 2007 AAHA/AAFP Pain Management Guidelines for Dogs and Cats was employed in an effort to increase the sensitivity and specificity of the diagnosis of back pain.[25] However, the corresponding author (NM) was aware of the clinical status of the animals during the clinical examinations and while extracting information from the medical records. Also, owing to the retrospective design of the study, it was not always possible to be certain that the development of back pain or adverse behavior was preceded by the surgery. Despite these concerns, we believe that owing to the magnitude of the ORs reported in this study, the consistency of results with previous reports and the biological plausibility of our findings that this study provides strong evidence that declaw surgery is associated with adverse outcomes. Although there may be some inaccuracies in the estimates of the ORs, we do not believe that these will have been sufficient to negate or reverse our findings. All of the outcomes for this study were decided upon during the design of the study, and not after the data had been collected. Rather than discovering one or two weak associations, the ORs related to all hypotheses were substantial and statistically significant.

The association of retained P3 fragments with the occurrence of back pain has not been previously reported. Although the ORs related to back pain were among the lowest in the study, they were too high to be the result of biased data. The presence of back pain is neither a reported nor a plausible reason for recommending onychectomy and we do not believe it reasonable to conclude that biased clinical assessment can account for the magnitude of the OR related to this outcome; that is, that the investigator was 2.9 times more likely to diagnose back pain in a declawed cat than in a non-surgical control. With regard to the consistency and plausibility of our findings, pain and inappropriate behaviors have been reported as adverse outcomes following declaw surgery. Importantly, none of the adverse behaviors, including aggression (unprovoked attacks), have been reported in the published literature as reasons for having cats declawed. If cats prone to unprovoked attacks, a highly undesirable trait, were three times more likely to be declawed than other cats, this sequence of events would almost certainly have been reported. Finally, the greater impact of poor vs optimal surgical technique on the odds of back pain and adverse behavior is plausible and further supports our conclusion that declaw surgery is related to the development of adverse outcomes for cats.

The significant but independent increases in the odds of back pain and barbering observed among animals housed in the shelter compared with owned cats were unexpected. In fact, the prevalence of all adverse outcomes were numerically increased in approximately equal proportions in both declawed and non-declawed cats in the shelter compared with the home environment. A potential explanation for this finding may be related to increased frequency and expertise in observing and recording or reporting these outcomes by shelter staff compared with owners. Whatever the explanation, it is important to note that inclusion of the location term in the models did not result in significant interaction or confounding and, therefore, the ORs relative to the impact of onychectomy were similar across the two locations.

Conclusions

This study found that declaw surgery in cats was associated with a significant increase in the odds of developing adverse behaviors, including biting, barbering, aggression and inappropriate elimination, as well as signs of back pain. There was a high prevalence of P3 fragments in declawed animals in this study and this was associated with an increase in all adverse outcomes in these animals compared with the non-surgical controls. As well, declawed cats with retained P3 fragments had higher odds of back pain, inappropriate elimination and aggression when compared with declawed cats without retained fragments. Although cats receiving optimal surgical technique had fewer adverse outcomes and lower odds of these outcomes being present, these animals were still at increased odds of biting and undesirable habits of elimination as compared with non-surgical controls. We propose that persistent pain and discomfort subsequent to declaw surgery is an important risk factor for the development of behavioral changes such as biting, aggression, barbering and inappropriate elimination. These are common reasons for the relinquishment of cats to shelters. In view of these findings, the ongoing practice of declawing cats in North America should be further questioned.

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