Surgical excision is the mainstay of treatment for primary skin neoplasia in cats. Curative-intent surgical treatment requires removal of all neoplastic tissue. The completeness of surgical excision is evaluated following histologic processing of excised tissues. Margins of submitted specimens are evaluated microscopically to determine whether neoplastic cells extend to the cut edge and whether the surgical goal was achieved.

Margin status is considered one of the most important components of a veterinary pathology report and is an important prognostic indicator for local disease recurrence and progression. The margin should be reported quantitatively as the smallest distance between the nearest neoplastic cell and the surgical margin. Quantification of the surgical margin is directly influenced by the phenomenon of specimen shrinkage. Tissue shrinkage is the decrease in dimensions of the tissue after surgical excision and histologic processing. The magnitude of tissue shrinkage in a given specimen directly influences the measurement of the surgical margin reported by a veterinary pathologist.

OBJECTIVE
To determine changes in dimensions of feline skin samples as a result of histologic processing and to identify factors that contributed to changes in dimensions of skin samples after sample collection.

SAMPLE
Cadavers of 12 clinically normal cats.

PROCEDURES
Skin samples were obtained bilaterally from 3 locations (neck, thorax, and tibia) of each cadaver; half of the thoracic samples included underlying muscle. Length, width, and depth were measured at 5 time points (before excision, after excision, after application of ink to mark tissue margins, after fixation in neutral-buffered 10% formalin for 36 hours, and after completion of histologic processing and staining with H&E stain). Measurements obtained after sample collection were compared with measurements obtained before excision.

RESULTS
At the final time point, tissue samples had decreased in length (mean decrease, 32.40%) and width (mean decrease, 34.21%) and increased in depth (mean increase, 54.95%). Tissue from the tibia had the most shrinkage in length and width and that from the neck had the least shrinkage. Inclusion of underlying muscle on thoracic skin samples did not affect the degree of change in dimensions.

CONCLUSIONS AND CLINICAL RELEVANCE
In this study, each step during processing from excision to formalin fixation and histologic processing induced changes in tissue dimensions, which were manifested principally as shrinkage in length and width and increase in depth. Most of the changes occurred during histologic processing. Inclusion of muscle did not affect thoracic skin shrinkage. Shrinkage should be a consideration when interpreting surgical margins in clinical cases.
of histologic margins and recurrence rates and known tissue shrinkage patterns for a given neoplasm.\textsuperscript{22-24} In veterinary medicine, there is a lack of precise guidelines for excision of all tumor types.\textsuperscript{1} However, data on recurrence rates for certain tumor types based on final histologic margins have been reported,\textsuperscript{25,26} and these data can be used to gauge whether tumor recurrence is probable.

The authors are aware of only limited information on the relationship between in vivo margins and histologic margins and the variability induced by specimen shrinkage in samples obtained from dogs and cats.\textsuperscript{25,26} Therefore, interpretation of surgical margins is limited to information that can be extrapolated from other species. Because of differences between feline, human, and canine skin, the extent of tissue shrinkage differs among these species.\textsuperscript{27} Specifically, feline skin has more dense and coarse collagen bundles as well as larger erector pili muscles.\textsuperscript{27} Additionally, samples obtained from the dorsal cervical and scapular regions of cats are characterized by smaller, more loosely arranged collagen bundles, which allow greater skin elasticity.\textsuperscript{27}

The objective of the study reported here was to investigate the nature of feline tissue shrinkage in skin samples subjected to routine histologic processing. Furthermore, we sought to identify the points during histologic processing at which shrinkage occurs by measuring dimensions of the samples at various times throughout the entire process. Finally, we wanted to determine the influence of factors such as topographic site and inclusion of underlying muscle on the degree of shrinkage.

**Materials and Methods**

**Animals**

Cadavers of 12 clinically normal adult specific pathogen-free purpose-bred domestic shorthair female cats were used in the study. Cadavers were obtained immediately after cats were euthanized at the completion of an unrelated study. All cats were 14 months old. Median body weight was 3.2 kg (range, 2.4 to 4.8 kg), and median body condition score (scale, 1 to 9) was 4 (range, 4 to 6). Physical examination performed prior to euthanasia revealed that cats were free of grossly apparent dermatologic disease.

**Collection of skin samples**

Cadavers were placed in lateral recumbency, and hair was clipped from 6 areas. Skin samples were obtained from 3 sites bilaterally (6 samples/cadaver); these sites were the lateral aspect of the neck, lateral aspect of the thorax, and proximolateral aspect of the tibia (Figure 1). Samples collected from the neck were centered over a point equidistant between the acromion of the scapula and wing of the atlas. Samples collected from the thorax were centered over a point 5 cm caudal to and at the level of the olecranon. Samples collected from the tibia were centered over a point 2.5 cm caudal to and at the level of the tibial tuberosity.

All samples were elliptical and orientated with the long axis in a cranial-to-caudal direction (median plane). Samples collected from the neck and tibia were 80 mm in length (median plane) and 40 mm in width (dorsal-to-ventral direction; dorsal plane). Samples collected from the thorax were 120 mm in length (median plane) and 60 mm in width (dorsal-to-ventral direction; dorsal plane). Depth of samples (transverse plane) was defined as including the dermis, subcutaneous tissue, and fascia.

A plastic template was used. A surgical skin marker\textsuperscript{2} was used to draw the ellipse over each location. The skin was incised with a No. 10 scalpel blade. The incision was made to the desired depth, which was to the level of the fascia in the neck and tibia locations. For samples collected from the thorax, the left or right side was randomly assigned (by coin toss) to include the underlying latissimus dorsi muscle. The tissue was then undermined and the excision completed by incising the skin, subcutis, and muscle (when included) with Metzenbaum scissors. Immediately after skin samples were obtained, 1 drop of tissue ink\textsuperscript{8} was used to mark the cranial, caudal, dorsal, and ventral aspects of each sample (a different color was selected for each aspect for consistent orientation during subsequent measurements).

**Measurements**

Tissues were measured to the nearest millimeter with a ruler\textsuperscript{4} by 1 investigator (SJ). Measurements were made in triplicate, and the mean was calculated. Measurements included the longest measurement in the median plane (length), dorsal plane (width), and transverse plane (depth).

Samples were measured at 5 times points: 0 = after
the proposed elliptical incision site was drawn with the marker (length and width) or after the skin incision was made to the desired depth (depth), 1 = after completion of excision (samples were placed on a flat glass surface, and 1 to 2 mL of sterile saline [0.9% NaCl] solution was added to reduce surface tension), 2 = after ink was applied to mark the margins of the samples and 10 minutes was allotted for the ink to dry, 3 = after fixation in neutral-buffered 10% formalin (volume of formaldehyde was 10 times the sample volume) for 36 hours, and 4 = after completion of histologic processing, embedding in paraffin, and staining with H&E stain.

Tissue transection and histologic processing

After fixation (time 3) was completed, each skin sample was transected and the segments were used to measure the width, length, and depth. Each skin sample was first transected along the dorsal plane, and the segments were used to measure the width (Figure 2). The skin sample was then transected along the median plane, and the segments were used to measure the length. Measurements for these tissue segments were summed to yield total width or length of a skin sample. One of the width segments was used in transverse orientation for measurement of the depth.

Segments too long to fit in a standard cassette for histologic processing and embedding in paraffin were bisected. Samples were placed in a calibrated automated processor. Samples were dehydrated by gradually increasing the concentration of alcohol solution from 80% to 95% and then to 100%. Xylene was used to remove the alcohol, which was followed by embedding in paraffin. Each sample was placed in a well, which was then filled with paraffin. A microtome was used to obtain 4-µm-thick tissue sections, which were initially placed in a water bath. Tissue sections were then mounted on slides, deparaffinized, and rehydrated prior to staining with H&E stain. Each slide was scanned, and measurements were obtained with digital pathology software by 1 investigator (SJ).

Table 1—Mean ± SD measurements (mm) at 5 time points* for skin samples collected bilaterally at each of 3 locations from cadavers of 12 clinically normal cats (6 samples/cat cadaver; 24 samples/location).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Location</th>
<th>Time 0</th>
<th>Time 1</th>
<th>Time 2</th>
<th>Time 3</th>
<th>Time 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>Neck</td>
<td>80.00 ± 0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>74.26 ± 4.32</td>
<td>72.11 ± 5.01</td>
<td>70.06 ± 5.52</td>
<td>55.65 ± 5.22&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Thorax†</td>
<td>120.00 ± 0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>112.97 ± 14.91</td>
<td>109.19 ± 15.77</td>
<td>102.64 ± 13.75</td>
<td>82.22 ± 10.52&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Tibia</td>
<td>80.00 ± 0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>71.10 ± 3.89</td>
<td>69.38 ± 4.21</td>
<td>67.51 ± 5.05</td>
<td>51.05 ± 4.73&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Width</td>
<td>Neck</td>
<td>40.00 ± 0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>34.51 ± 1.71&lt;sup&gt;a&lt;/sup&gt;</td>
<td>34.33 ± 2.14&lt;sup&gt;a&lt;/sup&gt;</td>
<td>33.81 ± 1.86&lt;sup&gt;a&lt;/sup&gt;</td>
<td>28.42 ± 2.95&lt;sup&gt;a,b&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Thorax†</td>
<td>60.00 ± 0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>50.94 ± 2.86</td>
<td>50.17 ± 2.66</td>
<td>48.94 ± 2.95</td>
<td>41.83 ± 8.45&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Tibia</td>
<td>40.00 ± 0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>28.61 ± 2.18&lt;sup&gt;a&lt;/sup&gt;</td>
<td>28.59 ± 2.41&lt;sup&gt;b&lt;/sup&gt;</td>
<td>27.93 ± 2.81&lt;sup&gt;b&lt;/sup&gt;</td>
<td>21.85 ± 3.13&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Depth</td>
<td>Neck</td>
<td>2.00 ± 0.44&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.86 ± 0.32</td>
<td>1.83 ± 0.33</td>
<td>1.83 ± 0.31</td>
<td>3.25 ± 0.74&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Thorax†</td>
<td>3.06 ± 0.66&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.67 ± 0.74</td>
<td>2.81 ± 0.74</td>
<td>2.86 ± 0.66</td>
<td>3.90 ± 0.89&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Tibia</td>
<td>1.38 ± 0.40&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.26 ± 0.38</td>
<td>1.18 ± 0.33</td>
<td>1.07 ± 0.20</td>
<td>2.42 ± 0.55&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

*Samples were measured at 5 time points: 0 = after the proposed elliptical incision site was drawn with a skin marker (length and width) or after the skin incision was made to the desired depth (depth), 1 = after completion of excision (samples were placed on a flat glass surface, and 1 to 2 mL of sterile saline [0.9% NaCl] solution was added to reduce surface tension), 2 = after ink was applied to mark the margins of the samples and 10 minutes was allotted for the ink to dry, 3 = after fixation in neutral-buffered 10% formalin for 36 hours, and 4 = after completion of histologic processing, embedding in paraffin, and staining with H&E stain.†Thoracic samples were collected with or without the underlying latissimus dorsi muscle; results are for only the 12 samples collected without inclusion of the underlying muscle.

Statistical analysis

Data recorded included 3 measurements (length, width, and depth) at 6 anatomic sites (lateral aspect of the neck, lateral aspect of the thorax, and proximolateral aspect of the tibia for the right and left sides; 24 samples/location) at each of 5 time points. Data were analyzed with statistical software. Data were assessed for normality by means of the Shapiro-Wilk test. A mixed model for
repeated-measures analysis was used to evaluate effects of anatomic site, time point, and dimension measurement, with cat included as a random effect. The effect of time point on skin sample measurements was assessed by differences of least squares mean values. After normalizing data for the size at time 0, the effect of location was evaluated among the neck, thorax (without the inclusion of underlying muscle; n = 12 samples), and tibia by means of the Scheffé test for multiple comparisons. The effect of including a muscle layer was determined via comparisons of samples obtained from the thorax by means of the Scheffé test for multiple comparisons. Values of \( P < 0.05 \) were considered significant.

**Results**

**Sample assessment**

Each sample was evaluated histologically to detect lesions or microscopic tissue artifact. There were no histologic lesions, and none of the samples contained profound distortion or separation of the tissues that would have influenced skin sample dimensions measured at time 4.

**Effect of location**

There were significant \( (P < 0.001) \) differences in the magnitude of change in sample dimensions at each location (Table 1). Length of samples at time 4 decreased by 30.4%, 31.5%, and 36.2% for the neck, thorax, and tibia locations, respectively, compared with the length at time 0. Width of samples at time 4 decreased by 29.0%, 30.3%, and 45.4% for the neck, thorax, and tibia locations, respectively, compared with the width at time 0. Depth of samples at time 4 decreased by 62.5%, 27.5%, and 75.4% for the neck, thorax, and tibia locations, respectively, compared with the depth at time 0. Pairwise comparisons revealed significant \( (P = 0.01) \) differences in width between the neck and tibia at each time point after excision.

**Effect of time**

There was a significant \( (P < 0.001) \) decrease in length and width of all samples from time 0 to time 4 (Table 1). Similarly, there was a significant \( (P < 0.001) \) increase in depth of all samples from time 0 to time 4.

**Effect of dimension**

The magnitude of change differed significantly \( (P < 0.001) \) among the 3 dimensions. The most substantial decrease was in width. Mean decrease in width of skin samples at time 4, compared with the width at time 0, was 34.21%. In comparison, mean decrease in length of skin samples at time 4, compared with the length at time 0, was 32.40%. There was a decrease in depth at time 1, 2, and 3, compared with the depth at time 0. From time 3 to 4, mean depth increased; thus, mean increase in depth at time 4, compared with the depth at time 0, was 54.95%.

**Effect of inclusion of underlying muscle**

There was no significant difference in dimensional changes between time 0 and time 4 between thoracic skin samples with or without the underlying muscle (Table 2). Compared with measurements at time 0, length and width of samples that included the underlying muscle decreased at time 4 by 33.0% and 32.2%, respectively. In comparison, length and width of samples without the underlying muscle decreased by 31.5% and 30.3%, respectively. Depth at time 4, compared with the depth at time 0, increased by 22.0% and 27.5% in thoracic samples with and without the underlying muscle.

**Discussion**

The present study confirmed that there were substantial alterations in dimensions of feline skin samples following excision and histologic processing. This study was closely modeled after a study conducted on canine skin to allow for interspecies comparisons. Similar to that canine study, there was a decrease in length and width and an increase in depth of feline skin samples. The underlying cause of this effect may have been associated with the excision and manipulation of tissues and inherent retractile properties of skin. Additionally, dehydration of the samples through immersion in alcohol and the fixation process may have led to further changes to the structure of the skin samples. The decrease in length and width of the skin samples (known as the lateral margins) decreased by a mean of 35.8% and 32.6%, respectively, following excision and histologic processing. However, depth of the skin samples increased by a mean of 55.1%. This is similar to the pattern reported for dogs whereby the length and width decreased by 26.5% and the depth increased by 65.3%. The decrease in length and width of skin samples is consistent with results of similar studies of humans in which lateral margins decreased (range,

Table 2—Mean ± SD measurements (mm) at each of 5 time points for skin samples with or without the underlying latissimus dorsi muscle obtained from the thoracic region of cadavers of 12 clinically normal cats.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Inclusion of muscle</th>
<th>Time 0</th>
<th>Time 1</th>
<th>Time 2</th>
<th>Time 3</th>
<th>Time 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>Yes</td>
<td>120.00 ± 0.00</td>
<td>103.92 ± 7.84</td>
<td>99.94 ± 8.07</td>
<td>96.03 ± 10.65</td>
<td>80.44 ± 9.92</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>120.00 ± 0.00</td>
<td>112.97 ± 14.91</td>
<td>109.19 ± 15.77</td>
<td>102.64 ± 13.75</td>
<td>92.22 ± 10.52</td>
</tr>
<tr>
<td>Width</td>
<td>Yes</td>
<td>60.00 ± 0.00</td>
<td>49.28 ± 3.42</td>
<td>48.78 ± 3.32</td>
<td>47.89 ± 2.86</td>
<td>40.69 ± 6.66</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>60.00 ± 0.00</td>
<td>50.94 ± 2.86</td>
<td>50.17 ± 2.16</td>
<td>48.94 ± 2.95</td>
<td>41.83 ± 8.45</td>
</tr>
<tr>
<td>Depth</td>
<td>Yes</td>
<td>3.14 ± 0.77</td>
<td>2.81 ± 0.61</td>
<td>2.89 ± 0.64</td>
<td>2.94 ± 0.62</td>
<td>3.83 ± 1.08</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>3.06 ± 0.66</td>
<td>2.67 ± 0.74</td>
<td>2.81 ± 0.74</td>
<td>2.86 ± 0.66</td>
<td>3.90 ± 0.89</td>
</tr>
</tbody>
</table>

See Table 1 for key.
15% to 25% of the original dimension). However, an increase in depth of tissue has not been consistently found in human samples.

The measurement of depth in the present study was performed in a manner similar to that for the other measurements. It was difficult to accurately measure the depth in situ prior to completion of the excision. The value at time 0 was used to calculate the decrease from the original depth (and therefore could have been a source of measurement error) and calculation of the overall change for each time point thereafter. Depth could have been accurately measured with another modality such as CT or ultrasonography, which may be clinically applicable in patients in which preoperative diagnostic imaging is used.

Overall, there was an increase in depth of the samples from time 3 to 4. This finding was also noted in the canine study, whereby the samples had a thicker depth but smaller width and length. A plausible explanation for the increase in depth of samples after tissue processing was the reexpansion and possible overexpansion that may have occurred when samples were placed in the water bath after sectioning with a microtome. However, this step was standardized to limit the amount of time that each sample was allowed to remain in the water bath. Furthermore, no consequential tissue separation or artifact was detected during final histologic examination.

In clinical cases, the presence of a fascial plane is important when interpreting the surgical margin with regard to depth. The presence of fascia may act as a biological barrier in some cases and is evaluated to determine the completeness of excision. In the present study, depth increased following excision and histologic processing, compared with the depth in situ. Overestimation of depth should be a consideration when interpreting the reported depth margin in a histologic processing, compared with the depth in situ. Overestimation of depth should be a consideration when interpreting the reported depth margin in a histology report. However, this should be combined with assessment of the presence of 1 or more fascial planes in the surgically excised tissue.

The neck, thorax, and tibia were chosen as locations to allow comparison with the canine study and to represent 3 distinct locations. Skin samples obtained from the tibial location had a significantly greater amount of shrinkage in width and length, compared with shrinkage in width and length for skin samples obtained from the neck, at times 2, 3, and 4. Skin samples obtained from the thorax had an intermediate amount of shrinkage, which is similar to results for the canine study. This finding in the present study is consistent with results of a human study in which investigators found that samples obtained from the extremities have a greater amount of shrinkage, compared with the amount of shrinkage for samples obtained from the trunk. In humans, this is thought to be attributable to the inherent contractility of tissue after excision. However, this theory is less plausible for the feline skin samples of the present study in which times 3 and 4 (rather than time 1) had the greatest difference from time 0, which suggested that the samples from the tibia underwent a greater degree of shrinkage during transection, fixation, dehydration, microtome sectioning, embedding, and staining.

Dimensions of the skin samples and the locations selected for the study reported here were the same as those for the aforementioned canine study. These were chosen to allow for direct comparison of results. However, sample size may be a variable in determining the magnitude of shrinkage, as has been mentioned for a human study. The long axis of the ellipse was oriented in the median plane. This was perpendicular to the lines of tension in the neck and thorax locations.

The orientation of the specimens in the present study does not typically mimic the clinical situation but was chosen to allow skin samples of the same size to be obtained and to compare results with those of that canine study. In the canine study, a greater amount of shrinkage occurred in the plane of tension, given that the short axis was oriented in the plane of tension. In the present study, total shrinkage was similar in both planes, which suggested that the plane of tension did not influence the degree of shrinkage. However, a future study in which samples are orientated in the median plane as well as perpendicular to the lines of tension would be required to evaluate whether the plane of tension influences the magnitude of sample shrinkage.

Similar to the canine study, most changes occurred between times 3 and 4. This correlates with the supposition that histologic processing was responsible for most of the changes to the samples in the present study. This can be attributed to the dehydration process, which may distort samples, as well as paraffin embedding, which may affect the structure of collagen and distort samples. In contrast, a recent study of feline skin samples conducted to investigate shrinkage in a single plane found that most shrinkage occurred following excision.

Inclusion of the underlying muscle at the thoracic location did not influence alterations in dimensions. This finding was surprising, given that results of the canine study indicated that inclusion of the underlying muscle reduced sample shrinkage. One explanation could be a type 2 error in the present study; however, this seemed unlikely given the sample size. Another explanation for the differing results between the canine study and the present feline study is the relative difference in thickness of subcutaneous tissues and the cutaneous trunci and latissimus dorsi muscles in Labrador Retrievers, compared with their thickness in domestic shorthair cats. The cutaneous trunci and latissimus dorsi muscles are relatively thinner in cats; therefore, the influence of these muscles on the magnitude of shrinkage may have been smaller.

In the present study, a scalpel blade and scissors were used to excise skin samples. In clinical practice, cutting diathermy, coagulation diathermy, or application of a carbon dioxide laser or harmonic scalpel may be used to excise cutaneous neoplasms. Use of these methods can induce cellular damage, including con-
denervation, hyalinization, and loss of fibrillar texture of collagen at the surgical margin.\textsuperscript{55} Additionally, thermally induced contraction of collagen results in irregular shrinkage patterns.\textsuperscript{33} In a study\textsuperscript{54} conducted to investigate various modalities, cutting diathermy resulted in the cleanest transection with the least amount of shrinkage. Comparatively, use of a scalpel resulted in the greatest amount of shrinkage.\textsuperscript{34} Therefore, the data in the present study cannot be extrapolated to clinical situations in which other methods are used for surgical excision. However, in the present study, use of a scalpel blade and scissors was chosen because this method of tissue excision remains one of the most common in veterinary medicine.

A strong correlation has been found between excision margins infiltrated by neoplastic cells and a high recurrence rate.\textsuperscript{25,26} The final histologic margin is used by clinicians to determine whether the excision is complete and whether local recurrence is likely.\textsuperscript{9} One study\textsuperscript{25} in which investigators examined skin neoplasms, including soft tissue sarcomas, carcinomas, and mast cell tumors, of dogs and cats found that margin status was the best predictor of local recurrence. In that study,\textsuperscript{25} the histologic margin was defined as close when tumor cells extended to within 2 mm of the surgical margin. Data from studies that link recurrence rate to histologic margin may be useful in determining the likelihood of recurrence. However, the present study highlighted the variability in the magnitude of shrinkage, depending on the location of the excision, which may need to be taken into account when interpreting the final histologic margin and determining the likelihood of local recurrence.

The present study had some limitations. First, the study involved a small number of cats that were not representative of the general feline population. Age, breed, sex, and body weight were homogenous. Data from the present study may not be accurately extrapolated to other cats. Skin shrinkage during histologic processing may differ among breeds, particularly those with differing skin elasticity (eg, Devon Rex). Additionally, patients that are more likely to have neoplastic conditions may be older and may differ in degree of skin shrinkage. In humans, patients > 60 years old had decreased shrinkage, compared with shrinkage for younger patients.\textsuperscript{11}

Furthermore, in the present study, recommended\textsuperscript{29} formalin fixation time and volume ratio as well as standard histologic processing with an automated processor were used. However, in clinical practice, there may be variation in fixation time and formalin volume ratio, which may influence the overall magnitude of shrinkage. Specifically, if there is inadequate fixation, samples may undergo autolysis.\textsuperscript{29} Additionally, interlaboratory variation in tissue processing may affect final patterns of tissue shrinkage.\textsuperscript{35}

The study reported here was performed with samples obtained from recently euthanized cats. All skin samples were collected within 30 minutes after cats were euthanized. Although it is unlikely to have influenced the results, there may have been cell autolysis and decomposition, which can influence the degree of skin shrinkage. The dermis and epidermis do not undergo histologic alterations during the first 6 to 8 hours after death.\textsuperscript{29} Furthermore, in the present study, there was no evidence of cell autolysis during histologic examination of the samples at time 4.

Another source of error for the present study was the standardization of skin sample collection and measurement. Distortion of the skin during excision was minimized by use of a template to outline the proposed skin incision. Additionally, skin samples were manipulated minimally during collection and measurement. To eliminate interobserver error, samples were measured by only 1 investigator. The investigator was potentially aware of the source of each sample, which provided a potential source of bias.

Although the study was conducted with samples obtained from cats that had no dermatologic abnormalities, the data can be extrapolated to patients with neoplastic conditions of the skin because the tissue of interest when assessing and measuring surgical margins should be nonneoplastic tissue. Nonneoplastic tissue may shrink more than neoplastic tissue.\textsuperscript{15,18} This is hypothesized to occur as a result of the inflexible structure of tissue protein, lipid, and water in neoplastic tissue, which allows the tissue to retain its original shape.\textsuperscript{15} However, in the zone of transition between neoplastic and nonneoplastic tissues, there may be other pathological processes (eg, inflammation) that are also associated with variations in the pattern of shrinkage.

The objective of the study reported here was to evaluate changes in the size of feline skin samples after excision and routine histologic processing. Furthermore, we compared these changes with those reported for dogs.\textsuperscript{28} To the extent feasible, the methods used in the present study were the same as those for that canine study.\textsuperscript{28} Findings of the present feline study and the previous canine study\textsuperscript{28} were similar but with different magnitudes. Length and width decreased and depth increased in samples obtained from each site (neck, thorax, and tibia) of the cat cadavers. A greater amount of change from the original dimensions was detected for the samples obtained from the tibia. Although changes occurred following excision, most of the changes to the dimensions of samples occurred following processing, including the steps of dehydration, microtome sectioning, paraffin embedding, and rehydration. Although these data may help guide interpretation of surgical margins for samples obtained from cats, further investigation of this phenomenon in clinical cases in a wider population of cats is required.

\textbf{Acknowledgments}

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Supported by the Auburn University Clinical Sciences Resident Research Fund.

The authors thank Dr. George Moore for assistance with the statistical analysis and Cynthia Hutchinson for technical assistance with histologic processing.

Footnotes
a. Devon surgical skin marker, Covidien, Mansfield, Mass.
b. Margin marker, Vector Surgical LLC, Wakeisha, Wis.
c. Devon skin marker ruler, Covidien Ltd, Mansfield, Mass.
d. Visiomorph DP, Visiopharm, Horsholm, Denmark.
e. SAS, version 9.3, SAS Institute Inc, Cary, NC.

References