Relation between size of skin excision, wound, and specimen

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Background: Skin wounds differ in shape and size compared with the planned excision, and skin shrinks after excision and fixation.
Objective: This study was designed to quantify and to analyze the differences between the size and shape of the planned excision, wound, and specimen.
Methods: Eighty-six patients with 93 benign or malignant skin tumors were prospectively studied. Length and width measurements were made of the lesion, planned surgical excision, postexcision wound, and prefixation and postfixation specimens. The results were analyzed to identify the effects of patient age and sex, and lesion type and site.
Results: Wound size was larger than planned excision size in 90% of wounds, and this effect was greatest in young patients and at trunk and limb sites. Excision and fixation caused the specimens to shrink so that the postfixation area was on average 48% of the planned excision area; benign tumors shrank more than malignant tumors.
Conclusion: Significant differences among planned excision, wound, and specimen sizes are influenced by patient age and by lesion site and type. These results demonstrate that wound size is not equivalent to tumor size, a conclusion often made in Mohs surgery. Furthermore, assessment of tumor clearance margins from fixed tissue does not reflect in vivo clearance margins.
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Wounds differ in shape and size after excision, and the excised skin shrinks when removed and after fixation.[1] These phenomena are widely recognized but to our knowledge have never been quantified. If substantial differences exist between the planned and actual wound size and shape, it follows that the closure technique cannot be confidently predicted before lesion excision. In addition, if the in vivo and excised fixed tissue dimensions differ significantly, assessment of tumor margin clearance from fixed specimens will be misleading, particularly if there are differences in the normal and tumor tissue responses to formaldehyde fixation.[2, 3]

To investigate some of these phenomena, we studied the relation among the size and shape of planned excisions, wounds, and specimens in patients undergoing cutaneous surgical procedures. Because wound size appeared to be influenced by diathermy hemostasis, its effect on wound size was also measured.

METHODS

Eighty-six patients (45 women, 41 men; mean age, 67 years; range, 18 to 98 years) having 93 skin lesions excised were prospectively studied for 9 months. Lesion and planned surgical excision length and width were measured before local anesthetic (2% lidocaine with 1:80,000 epinephrine) injection. All excisions required full-thickness skin excision down to fat or deep fascia. After excision the wound and specimen length and width were measured. In 40 patients (29 with head and neck wounds, 11 with wounds on the trunk and limbs) in whom bipolar diathermy was required, wound dimensions were also recorded after hemostasis. After at least 16 hours in 10% formalin, the fixed tissue specimen was measured with a ruler by the pathologist. All other length and width measurements were made by placing a straight piece of sterile paper or card along the distance to be measured, snipping the edge at the appropriate point, and measuring the distances to the nearest 0.5 mm. The measured shapes

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Table I. Geometric means for the 93 specimens

	Length × width (mm)		Calculated area (mm^2)	
	Mean	Range	Mean	Range
Lesion for excision	14 × 10	5 × 4-66 × 50	113	16-2592
Planned surgical excision	20 × 15	7 × 5-82 × 64	237	28-4122
Wound excision size	22 × 17	8 × 6-84 × 60	285	38-3959
Prediathermy wound (n = 40)	20 × 15	8 × 6-84 × 60	248	38-3959
Postdiathermy wound (n = 40)	19 × 14	8 × 6-81 × 61	213	38-3881
Excised tissue (n = 91)	18 × 13	7 × 5-76 × 55	184	28-3283
Fixed tissue (n = 86)	17 × 12	7 × 5-65 × 50	163	28-2553

Table II. Geometric means for lesions for excision, planned surgical excisions, postexcision wounds, excised tissue specimens, and fixed tissue specimens, grouped according to patient age, sex, and lesion site

	n	Age (yr)	Lesion (mm^2)	Planned excision (mm^2)	Postexcision (mm^2)	Excised tissue* (mm^2)	Fixed tissue* (mm^2)
All wounds	93	63	113	237	285	184	163
Patient gender							
F	48	64	105	220	267	171	147
M	45	61	122	257	306	199	182
Age (yr)							
≤50	22	36	69	174	236	128	125
51-70	32	61	94	198	226	152	136
≥71	39	79	175	326	384	262	224
Site							
Eyes/lip	4	56	69	165	162	123	118
Ears	16	72	171	319	358	258	243
Nose	10	65	61	123	127	104	93
Other facial	31	63	105	200	245	163	144
Neck/scalp	6	68	240	429	548	331	329
Trunk	12	44	73	226	325	161	147
Limbs	14	65	414	654	749	504	481
Benign	30	50	101	215	282	151	136
Malignant	63	69	120	248	286	201	176

*Sample size slightly varied because excised tissue values were not available in two cases and postfixation values were not available in seven cases.

were either elliptic or circular, and thus area *(A)* measurements were approximated from the length *(l)* and width *(w)* with the formula $A = \frac{1}{4}\pi lw$.

The wound area results showed a highly skewed distribution, so a logarithmic transformation was applied before analysis. Consequently the averages of measurement reported in Tables I and II are geometric means. Further analysis used multiple regression to account for the effects of age, sex, lesion type, and site.

RESULTS

All 30 benign (15 nevi, five squamous keratoses, five full-thickness graft donor sites, and five others) and 63 malignant lesions (57 basal cell carcinomas, five squamous cell carcinomas, and one other) were histologically completely excised. The mean calculated lesion area of 113 mm^2 (120 mm^2 for malignant lesions, 101 mm^2 for benign) was 52% less than the planned excision area of 237 mm^2 (248 mm^2 for malignant lesions, 215 mm^2 for benign). The mean minimum clearance margin was calculated from the smallest difference between the lesion and planned excision margin length or width and was 1.8 mm (range, 0 to 4.5 mm) for benign and 3.3 mm (range 2 to 7 mm) for malignant lesions. Lesion, wound, and specimen dimensions are summarized in Table I and Fig. 1. Wound area (mean, 285 mm^2; n = 93) was on average 20% greater than the planned excision area (mean, 237 mm^2; n = 93). An increase in size occurred in 85 of the 93 wounds, five remained

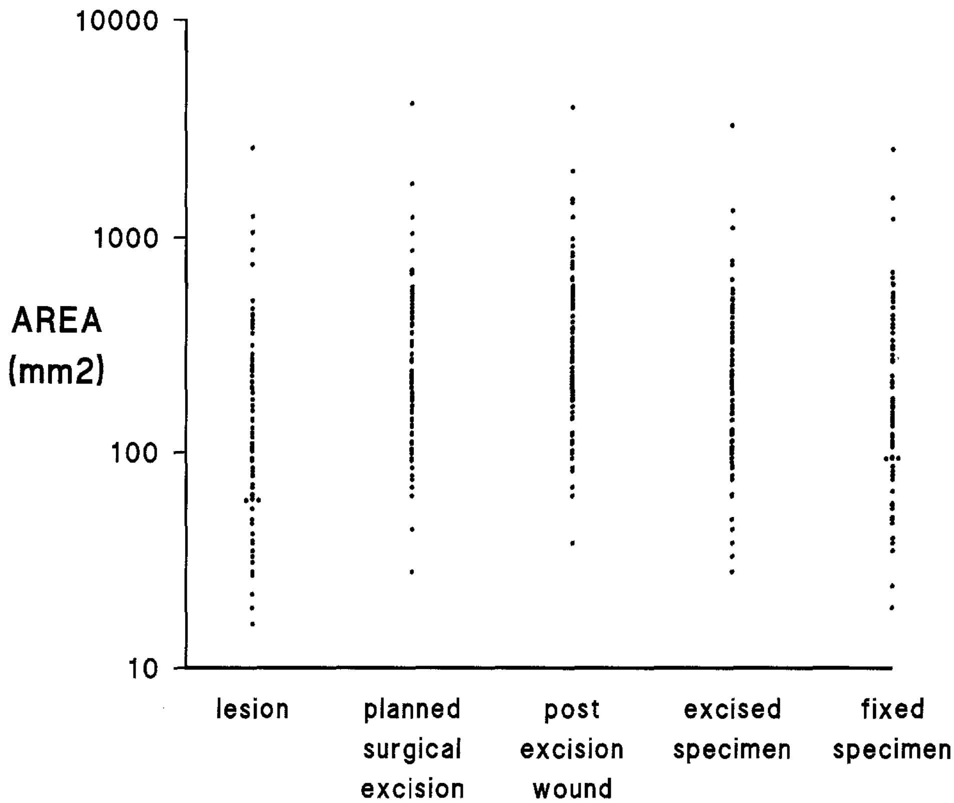

Fig. 1. Areas of each lesion, planned excision, actual wound, excised specimen, and fixed specimen calculated from measured lengths and widths and plotted on log scale on y-axis.

unchanged, and three were actually smaller. After diathermy the mean wound area decreased by 14%, from 248 to 213 mm^2 in the 40 wounds studied. Compared with the planned excision area, the specimens shrunk by 22%, from 237 to 184 mm^2, with a further 11% reduction compared with preexcision specimens after fixation, producing a total reduction in specimen size compared with planned excision size of 31%.

The effects of age, sex, lesion type, and site (Table II) on the changes in wound and specimen size were investigated with multiple regression. In these analyses the patient's age rather than the groupings in Table II was used; lesions were classified as either benign or malignant, and site was classified into four groups: limbs; trunk; eye, lip, nose, or ear; and neck, scalp, or other facial region.

Wound size

Difference between planned and actual wound size. The difference between planned and actual wound size was analyzed by the log of the ratio of the actual wound size to the planned wound size (RA). Although there was a marked difference between sites ($p = 0.007$), interpretation was complicated because of the suggestion that the difference between sites depended on the patients' age (interaction, $p = 0.06$). Further analysis showed that the interaction was caused by a strong age effect in the limb and trunk groups (Fig. 2, *A*), but there was no age effect on the head and neck sites (Fig. 2, *B*). From these results it was calculated that for limb and trunk sites the effect of age could be summarized by the following formula: $\log_{10}(RA) = 0.226 - 0.0018 \times$ Age in Years, so that wounds were larger than the planned excision size in all patients, but this effect was greater in younger subjects. For example, a trunk or limb wound was on average 55% greater than the planned excision size in a 20-year-old patient but only 16% larger in a 90-year-old patient. No evidence of any difference in the degree of expansion between limb and trunk sites was observed.

On the head and neck, wounds gaped more on the neck and scalp sites compared with other head and neck sites. The geometric mean of the actual/planned wound size ratio on the neck, scalp, or other facial regions was 1.23 (a 23% increase) compared

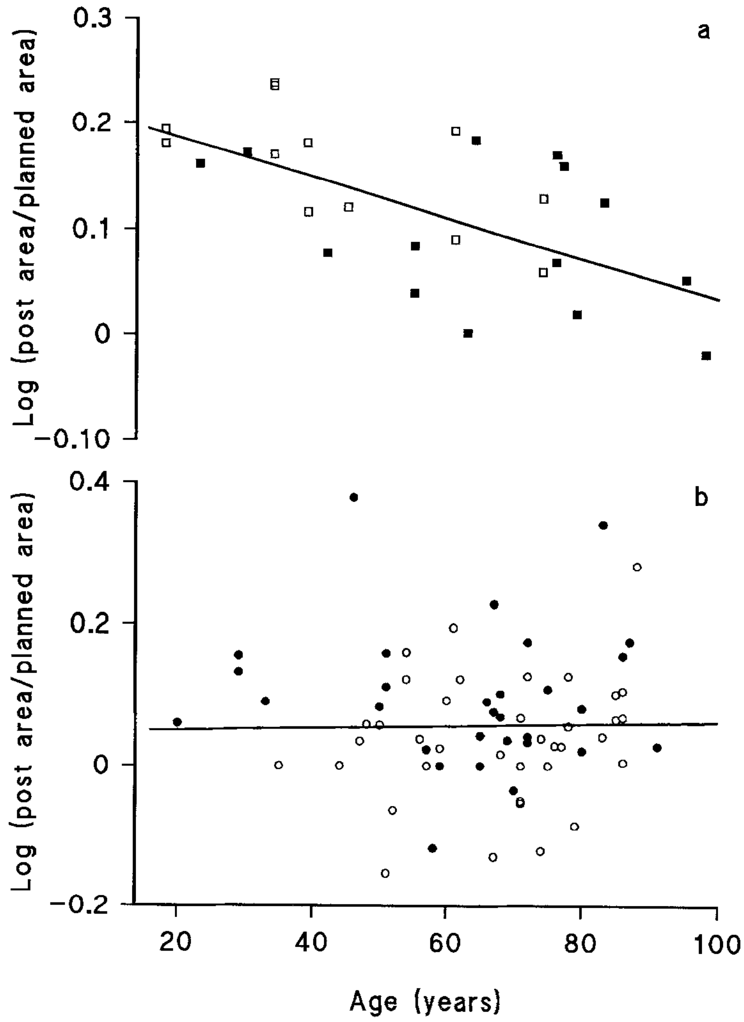

Fig. 2. **a,** Effect of increasing age on amount of wound expansion that occurs compared with planned excision for procedures carried out on limb (■) and trunk (□) sites. **b,** Effect of increasing age on amount of wound expansion that occurs compared with planned excision for procedures carried out on head and neck sites (●, eye, lip, nose, or ear; ○, neck, scalp, or other facial region).

with 1.07 (a 7% increase) on the eye, lip, nose, or ear, ($p = 0.009$; 95% confidence interval [CI] for ratio of geometric means, 1.03 to 1.28). When these differences because of site and age had been taken into account, there was no evidence that sex or tumor type influenced the extent to which wounds gaped after lesion excision.

Effect of diathermy on wound size. The effect of diathermy on wound size was measured in 40 patients (mean age, 68 years; range 19 to 98 years) in whom bipolar diathermy was used for hemostasis in wounds with a mean planned excision size of 202 mm^2. The mean wound area after diathermy (213 mm^2) was on average only 86% of the area immediately after excision (248 mm^2). Although the extent of wound contraction after diathermy was relatively small, this occurred in 34 of 40 wounds measured, and comparison of the difference in wound area before and after diathermy was significant (95% CI interval, 82% to 90%; $p < 0.001$). There was no evidence that diathermy-induced wound contraction was influenced by age, sex, lesion site, or type.

Specimen size

Prefixation specimen shrinkage. Ninety-one of the immediate postexcision and prefixation specimen sizes were available; two benign tumor specimen sizes were missing. The mean postexcision specimen area (184 mm^2) was 22% smaller than the

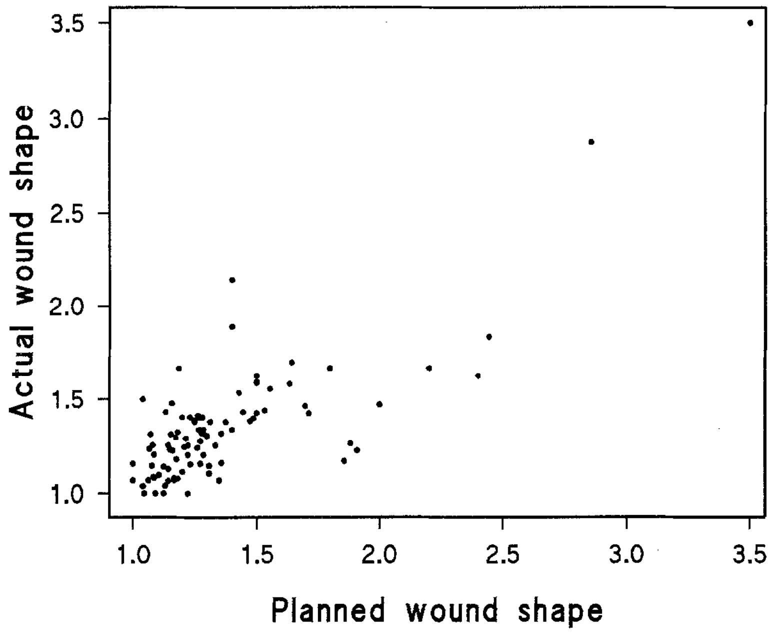

Fig. 3. Comparison of elliptic shapes of planned excision and actual wound after lesion excision. Value of 1 would indicate circular shape.

planned excision area (237 mm^2), but there was no evidence that the size of the reduction depended on age, sex, or lesion site. There was, however, evidence ($p = 0.004$) that the reduction was greater for benign (mean reduction to 72% of the planned excision area) than for malignant tumors (mean reduction to 81%).

Effect of fixation. The postfixation area was available in 86 specimens. Overall, specimens had shrunk compared with the planned excision size so that the mean postfixation area was 73% of the planned excision area (95% CI, 67% to 77%; $p < 0.001$). This effect was not influenced by the patient's age, sex, or lesion site. There was weak evidence that malignant tumors ($n = 61$) shrank less than benign ones ($n = 25$), so that the postfixation area was 75% of the planned area size for malignant tumors compared with 68% in benign tumors ($p = 0.088$). Thus benign tumors shrank 1.11 times more than malignant tumors (95% CI, 0.99 to 1.26).

Wound shape. Wound shape was studied by comparing the planned and actual wound length with width ratio, so that a circular wound with a ratio of 1 could become more elliptic with a ratio of greater than 1 (Fig. 3). The direction of the long axis of the wound was not recorded. There was no overall effect on wound shape when all the planned and actual wound ratios were compared. The geometric mean planned wound shape ratio of 1.33 was similar to the actual wound shape ratio of 1.32 (95% CI for the ratio of geometric means, 0.96 to 1.04; $p = 0.62$). No evidence of an effect on wound site or patient age was found.

DISCUSSION

This study shows that significant differences exist between planned excision, wound, and specimen sizes that are variably influenced by patient age and by lesion site and type. Ninety percent of the wounds were larger than the planned excision area. With advancing age, wounds gape less on limb and trunk sites but not on head and neck sites. The fixed specimens were 31% smaller than the planned excision size, with most (22%) of this shrinkage occurring after excision and before fixation. Although no sex, site, or age effects were observed, there was some suggestion that malignant tumors shrank less than benign tumors or normal skin. Surprisingly, there was little tendency for circular planned excision shapes to become elliptic wounds.

These observations confirm that significant differences exist in the planned and actual wound size. Wound size is commonly assumed to be equivalent to tumor size after Mohs surgical excision.[4-6] This study demonstrates that such an assumption results in an average 20% overestimate in tumor extent. Furthermore, many surgeons anticipate the wound closure before lesion excision.[7] Although it is important to consider all possible closure techniques, it is essential to recognize that because of wound expansion, commitment to a particular closure technique should occur only after lesion excision.[8] This may be particularly important with limb and trunk wounds in young persons in whom wound expansion is significantly greater, and if a circular excision is used, the predicted optimum wound closure direction may be different from that finally used.[9]

Malignant tumors shrank less than benign ones despite a wider margin of normal skin. Previous studies have examined normal marginal skin shrinkage after excision of malignant melanoma[2, 3] and found that only the patient's age and the in vivo diameter of the surgical specimen were found to influence independently the amount of specimen shrinkage. Different tumors may therefore exhibit different shrinkage tendencies after excision and after fixation.

Diathermy caused wounds to shrink to 86% of the wound size, bringing the wound area closer to the original planned excision size. No effect of site was observed; this finding largely excluded our original idea that wounds actively contracted because of facial striated muscle contraction induced by diathermy stimulation. Diathermy presumably induces fibroblast contraction in adjacent tissue. It seems unlikely that vaporization and destruction of remaining tissue[10] contributes significantly to this effect, because this appears to occur actively and during the first few seconds diathermy is used.

This study demonstrated significant differences between the planned and postexcision wound sizes and specimen size. With advancing age, limb and trunk wounds gape less and benign tumor specimens shrink more than malignant tumors, after excision and fixation. It seems probable that with experience surgeons intuitively anticipate the direction and extent that a wound will gape after lesion excision. However, our findings show that the potentially large differences between the planned and actual wound size and shape must be considered when wound closure is planned.

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