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ORIGINAL RESEARCH

A Scoring System That Predicts Difficult Lipoma Resection: Logistic Regression and Tenfold Cross-Validation Analysis

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ABSTRACT

Introduction: Most lipomas are readily dissected and removed. However, some cases can pose surgical difficulties. This retrospective study sought to identify clinical and radiological risk factors that predict difficult lipoma resection and can be used in a clinically useful scoring system that predicts difficulty preoperatively.
Methods: The study cohort consisted of all consecutive patients who underwent resection of pathology-confirmed lipoma during 2016–2018 at a tertiary care referral center in Tokyo, Japan. Surgical difficulty was defined as difficulty separating some/all of the tumor from the surrounding tissue by hand and inability to extract the tumor in one piece. Descriptive, univariate, and multivariate logistic regression analyses were conducted to identify predictive factors. The predictive accuracy of the scoring system that included these factors was assessed by tenfold cross-validation analysis. Receiver-operating curve (ROC) analysis was conducted to identify the optimal cutoff score for predicting surgical difficulty.
Results: Of the 86 cases, 36% involved surgical difficulty. Multivariate analysis showed that subfascial intramuscular location (odds ratio 42.7, 95% confidence interval 3.0–608.0), broad touching of underlying structures (46.5, 3.7–586.0), in-flowing blood vessels (9.3, 1.1–78.5), and unclear boundaries (109.0, 1.1–1110.0) significantly predicted surgical difficulty. These factors were used to construct a 0–4 point scoring system (with one point per variable). On cross-validation, the accuracy of the scoring system was 82.4% (Cohen's kappa of 0.57). ROC analysis showed that scores ≥ 2 predicted surgical difficulty with sensitivity and specificity of 55% and 98%, respectively.
Conclusions: Our scoring system accurately predicted lipoma resection difficulty and may help operators prepare, thereby facilitating surgery.

Keywords: Lipoma; Resection; Logistic regression analysis; Surgical difficulty; Scoring system

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Key Summary Points

Why carry out this study?

Lipoma is the most common of the benign mesenchymal tumors. While lipoma dissection is usually easy, some can be difficult to remove because they adhere strongly to the surrounding normal tissue.

The surgical difficulties of removing lipomas have not been reported previously.

This retrospective study was conducted to determine the frequency of surgical difficulties, identify the clinical and radiological factors that predict these difficulties, and generate a clinically useful scoring system that will help predict difficult resection before surgery.

What was learned from the study?

Of the 86 cases, 36% involved surgical difficulty. Multivariate analysis showed that subfascial intramuscular location, broad touching of underlying structures, in-flowing blood vessels, and unclear boundaries significantly predicted surgical difficulty.

Our scoring system accurately predicted lipoma resection difficulty and may help operators prepare, thereby facilitating surgery.

INTRODUCTION

Lipoma is the most common of the benign mesenchymal tumors, accounting for 48% of all such tumors [1, 2]. The vast majority (99%) occur in the subcutaneous tissue [3]. Most are treated with surgical resection. The dissection is usually easy, even when the lipomas are giant; indeed, the tumor can often be squeezed out through short incisions [4]. Occasionally, however, lipomas can be difficult to remove because they adhere strongly to the surrounding normal tissue. In addition, their removal can result in excessive bleeding. In such cases, the operation takes longer, which can become problematic if the surgery is conducted under local anesthesia.

The difficulties that can be faced when surgically removing lipomas have not been reported previously. This retrospective cross-sectional study was conducted to (i) determine the frequency of such difficulties, (ii) identify the clinical and radiological factors that predict these difficulties, and (iii) generate a clinically useful scoring system that will help predict difficult resection before surgery.

METHODS

Ethics

This study was approved by the ethics committee of Nippon Medical School, Japan (no. B-2020–210). It was performed in accordance with the Helsinki Declaration of 1964 and its later amendments. All patients gave written informed consent.

Patient Selection

The study cohort consisted of all consecutive patients who underwent surgical resection for suspected lipoma at Nippon Medical School Hospital (Tokyo, Japan) between April 2016 and September 2018 that was then confirmed by pathology to be a lipoma.

Operative Technique

The surgeries were performed by 34 plastic surgeons. The anesthesia approach (local or general) was decided by the operator. The tumor was accessed by making a straight or a lazy S incision line directly above the tumor. Primary closure was performed after tumor extraction. The same surgical instruments were used for all cases.

Data Collection

The prospectively maintained medical records were searched for the case details. Surgical difficulty was defined as difficulty separating at least some of the tumor from the surrounding tissue by hand and inability to extract the tumor in one piece. Since it was difficult to quantitatively evaluate the difficulty of extraction, difficulty was intentionally divided into two categories (difficult and not difficult). The degree of difficulty was confirmed independently with all operators. The following variables were recorded: patient age and sex; anesthesia (local or general); operating time; surgical difficulty; tumor location, volume, and depth (i.e., at the subcutaneous or subfascial level; subfascial location was in turn categorized as intermuscular or intramuscular); the imaging modality used to inspect the tumor [computed tomography (CT) or magnetic resonance imaging (MRI)] and whether it was plain or enhanced; the imaging findings; and postoperative complications. Operating time was defined as the time from the start of surgery to the moment the tumor was removed. In most cases, hemostasis was achieved before tumor removal; however, in cases that required new hemostasis after removal, operating time did not include this period. To categorize tumor location, we divided the whole body into eight parts: front of head, back of head, front of neck, back of neck, front of trunk, back of trunk, upper limb, and lower limb. Tumor volume was calculated on the basis of the tumor lengths in the axial, sagittal, and coronal planes; it was assumed that the mass was ellipsoidal. Surgical difficulty was a binary variable, while the patient/tumor variables were either continuous or binary.

Imaging Findings

We used reports describing difficult meningioma resection in the field of brain surgery [5, 6] to identify eight common imaging findings. These findings are: (i) degree of tumor contact with the underlying structures (e.g. deep fascia or periosteum), (ii) tumor is/is not partitioned (monolocular or multilocular), (iii)

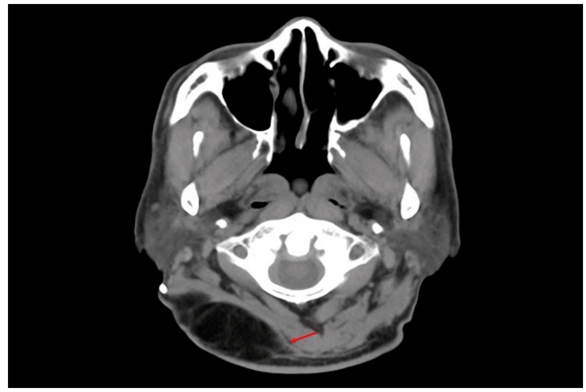

Fig. 1 Shaggy appearance of the tumor. Unenhanced CT scan shows a lipoma of the posterior neck. The interface between the tumor and its surrounding tissue (red arrow) has a shaggy appearance that is a sign of inflammation

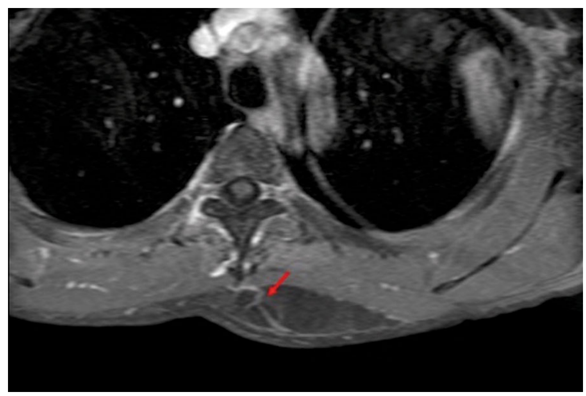

Fig. 2 In-flowing blood vessels. Axial contrast-enhanced T1-weighted MRI shows a lipoma of the upper back. The linear enhanced lesions (red arrow) indicate blood vessels that flow into the tumor

the tissue around the tumor does/does not have the shaggy appearance that indicates inflammation (Fig. 1), (iv) blood vessels do/do not flow into the tumor (Fig. 2), (v) the tumor does/does not extend beyond the midline of the trunk, (vi) the tumor does/does not have clear boundaries with the surrounding tissue (Fig. 3), (vii) normal fat tissue does/does not intervene between the tumor and the underlying structures (Fig. 4), and (viii) the tumor does/does not have an infiltrative pattern (Fig. 5). The first finding, namely degree of contact with underlying structures, was calculated as the ratio of the maximum tumor diameter to the tumor base

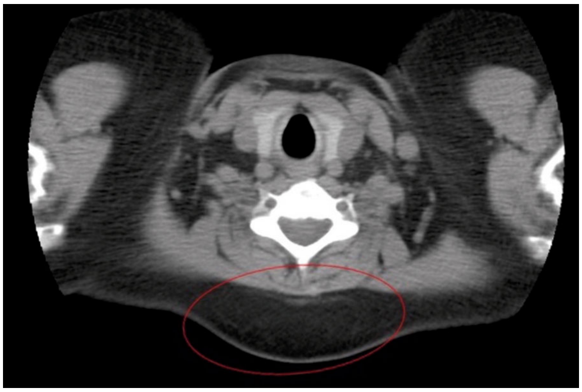

Fig. 3 Tumor has unclear boundaries with the surrounding tissues. Unenhanced CT shows a lipoma of the upper back. The boundaries between the tumor and the surrounding tissues (inside the red ellipse) are unclear

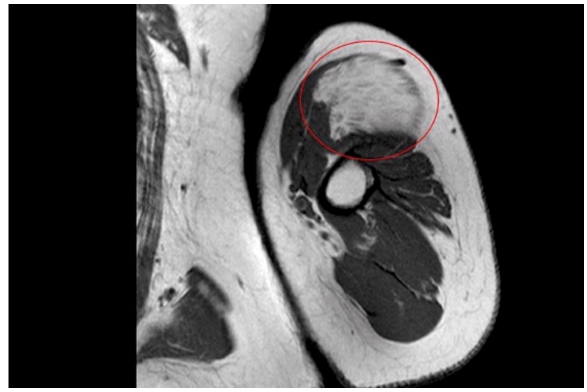

Fig. 5 The tumor has an infiltrative pattern. Axial T1-weighted MRI shows an intramuscular lipoma of the left shoulder. Its infiltrative pattern tends to invade adjacent musculature (inside the red ellipse)

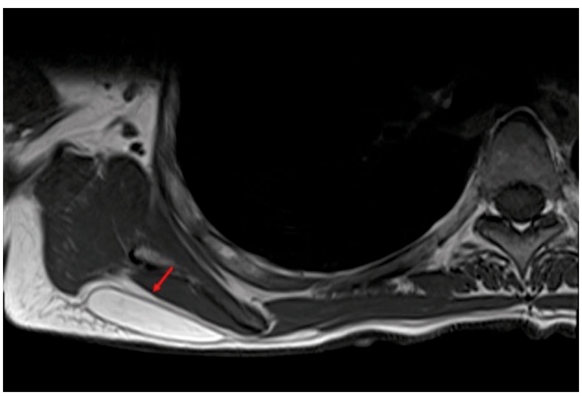

Fig. 4 Normal fat tissue intervenes between the tumor and the underlying structures. Axial T1-weighted MRI shows a lipoma of the left shoulder. Normal fat tissue lies between the lipoma and the underlying structures (red arrow)

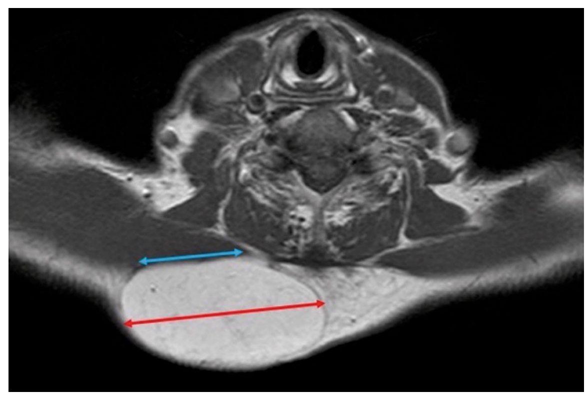

Fig. 6 The tumor touches the underlying structures minimally. Axial T1-weighted MRI shows a lipoma in the right shoulder. The maximum diameter of the tumor (red two-headed arrow) is 82 mm long. The length where the tumor base touches the underlying structures (blue two-headed arrow) is 39 mm long. This case belongs to the "minimally touching" category because the ratio of the maximum tumor diameter to the tumor base length that touches the underlying structures is 0.47 and thus below the 0.5 threshold

length that touched the underlying structure. Tumors with a ratio of < 0.5, 0.5–0.8, and > 0.8 were classed as minimally, moderately, and broadly touching tumors, respectively. Examples of minimally and broadly touching tumors are shown in Fig. 6 and 7, respectively. All tumors were categorized according to these eight imaging findings. Initially, the first 30 cases were evaluated by a board-certified radiologist (T.S.) and two board-certified plastic surgeons with respectively 7 and 17 years of experience (G.A. and S.O.) until consensus was obtained. These evaluations were blinded to patient information. The remaining cases were then evaluated by the two plastic surgeons.

Statistical Analyses

The first analysis was descriptive: all demographic, operative, tumor, and image variables were expressed as mean ± standard deviation or

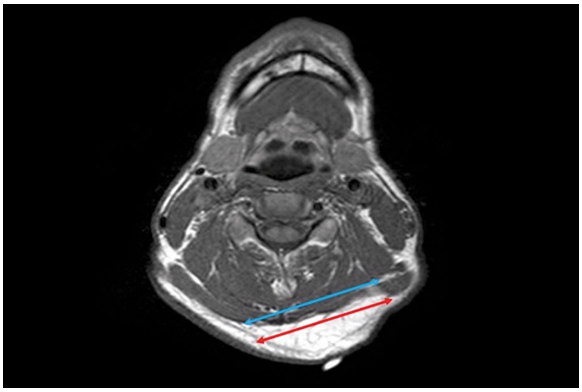

Fig. 7 The tumor touches the underlying structures broadly. Axial T1-weighted MRI shows a lipoma in the back of the neck. This case belongs to the "broadly touching" category since the ratio of the maximum tumor diameter (red two-headed arrow, 67 mm) to the tumor base length that touches the underlying structures (blue two-headed arrow, 67 mm) is 1.0 and therefore greater than the 0.8 threshold

n (% of cohort). The frequency of difficult surgery for each variable category was calculated. To determine the correlations between each variable and surgical difficulty, Pearson product moment correlations were conducted. We calculated the correlation between binary variables and continuous variables (biserial correlation) and the correlation between binary variables (phi coefficient). The risk factors that were identified in this analysis were then included as predictors in multiple logistic regression analysis. These data were expressed as odds ratio [95% confidence intervals (CI)]. If the predictive factors were considered to be useful, they were used to construct a scoring system that aims to predict surgical difficulty. A second logistic regression analysis was then performed with the factors included in this system. A tenfold cross-validation analysis was conducted with our case-series data to quantitatively assess the accuracy of the scoring system. In general, in *k*-fold cross-validation, the dataset is shuffled and split into *k* groups (ten in our case). Each unique group is used to train a model, which is then fit on the remaining groups, which together serve as the training dataset. The accuracy of the model with the remaining data subset (as measured by Cohen's kappa) is retained, and the model is discarded. This procedure is followed for each group. At the end, the mean kappa value is calculated. It has been suggested that kappa < 0.40, 0.10–0.75, and > 0.75 indicate poor, fair–good, and excellent accuracy, respectively [7]. Receiver-operating curve (ROC) analysis was also performed to investigate the diagnostic ability and to identify an optimal cutoff point. $P < 0.05$ was considered to indicate statistical significance. All statistical analyses were performed using R version 3.3.1 (The R Foundation for Statistical Computing, Vienna, Austria) [8].

RESULTS

In total, 121 patients underwent resection for suspected lipoma. Of these, seven cases were excluded because pathology indicated the tumor was an angiolipoma ($n = 5$) or a spindle lipoma ($n = 2$). In addition, 28 cases were excluded from analysis because imaging had not been performed ($n = 14$) or some details could not be obtained ($n = 14$). Thus, 86 cases for which complete information could be obtained were included in this study.

Patient, Tumor, and Lipoma Surgery Characteristics

The patients were on average 52 years old, 52% were male, general anesthesia was used in 59%, and mean operating time was 30 min. The surgery was deemed difficult in 31 cases (36%). Older age, male sex, general anesthesia, and longer operating time tended to associate with difficult lipoma resection (Table 1).

The tumor was located in seven of the eight body compartments, the exception being the front of the neck. The most common location was the back of the trunk. The location that associated most strongly with difficult surgery was the back of the neck (100%). Other locations that associated with difficult surgery were the back of the head, front of the head, and lower limb. Back of the trunk location was associated with the lowest frequency of difficult surgery (Table 1).

Table 1 Characteristics of the patients, their tumors, and the lipoma surgery

Variable	*n* (% of cohort) or mean ± SD	No. of difficult cases (% of total in imaging finding subcategory)
No. of patients	86	
Age, years	52 ± 13	
Age ≤ 52	43	13 (30)
Age > 52	43	18 (42)
Male sex	45 (52)	18 (58)
Female sex	41 (48)	13 (42)
General anesthesia	51 (59)	21 (68)
Local anesthesia	35 (41)	10 (32)
Operating time, min	30 ± 23	
≥ 30 min	48	12 (25)
< 30 min	38	19 (50)
No. of surgical difficulty cases	31 (36)	
Tumor location		
Front of head	10 (12)	5 (50)
Back of head	4 (5)	3 (75)
Front of neck	0	–
Back of neck	8 (9)	8 (100)
Front of trunk	17 (20)	5 (29)
Back of trunk	27 (31)	4 (15)
Upper limb	13 (15)	3 (23)
Lower limb	7 (8)	3 (43)
Tumor volume, cm^3	423 ± 745	
≤ 423 cm^3	47	16 (34)
> 423 cm^3	26	16 (46)
Tumor depth		
Subcutaneous	70 (81)	22 (31)
Subfascial	16 (19)	9 (56)
Intermuscular lipoma	7	0
Intramuscular lipoma	9	9 (100)
Imaging modality used; enhanced:nonenhanced		
CT	41 (48%); 40:1	

Table 1 continued

Variable	***n* (% of cohort) or mean ± SD**	**No. of difficult cases (% of total in imaging finding subcategory)**
MRI	45 (52%); 25:20	
Imaging findings		
Degree of contact		
Minimally touching	23 (27)	2 (10)
Moderately touching	13 (15)	6 (46)
Broadly touching	34 (40)	20 (59)
Tumor compartmentation		
Unilocular	61 (71)	19 (31)
Multilocular	25 (29)	12 (48)
Shaggy appearance		
Yes	11 (13)	9 (82)
No	75 (87)	22 (29)
In-flowing blood vessels		
Yes	16 (19)	12 (75)
No	70 (81)	19 (27)
Crossing trunk midline		
Yes	9 (10)	7 (78)
No	77 (90)	24 (31)
Unclear boundary		
Yes	9 (10)	8 (89)
No	77 (90)	24 (31)
Normal fat intervenes		
Yes	6 (7)	0
No	80 (93)	31 (100)
Infiltration pattern		
Present	2 (2)	2 (100)
Absent	84 (98)	29 (36)

CT computed tomography, *MRI* magnetic resonance imaging

Table 2 Univariate correlations between patient/tumor variables and surgical difficulty

Variables	Correlation coefficient	*P* value*
Age	0.09	0.453
Sex	0.08	0.430
Operating time	0.46	**0.00002**
Front of head	0.1	0.334
Back of head	0.18	0.099
Back of neck	0.42	**0.00004**
Front of trunk	−0.08	0.530
Back of trunk	−0.32	**0.005**
Upper limb	−0.1	0.296
Lower limb	0.12	0.699
Volume of the tumor	0.03	0.817
Subfascial location		
Intermuscular	−0.14	0.190
Intramuscular	0.29	**0.006**
Unenhanced CT	−0.06	0.529
Enhanced CT	−0.09	0.456
Unenhanced MRI	0.0006	0.996
Enhanced MRI	0.15	0.141
Broadly touching	0.37	**0.0003**
Minimally touching	−0.37	**0.001**
Multilocularity	0.14	0.143
Shaggy appearance	0.36	**0.0006**
In-flowing blood vessels	0.38	**0.0002**
Crossing the midline of the trunk	0.29	**0.006**
Unclear boundaries	0.37	**0.0004**
Normal fat tissue intervenes	−0.22	0.058
Infiltration pattern present	0.2	0.06
General anesthesia	0.12	0.237

P values less than 0.05 are shown in bold

CT computed tomography, *MRI* magnetic resonance imaging

*Pearson correlation analysis

Table 3 Scoring system used to predict difficult lipoma surgery

Factor	Point
Subfascial intramuscular location	1
Tumor broadly touching underlying structures*	1
In-flowing blood vessels	1
Unclear boundaries	1

*Defined as ratio > 0.8, where the ratio is the maximum tumor diameter to the tumor base length that touched the underlying structure

Mean tumor volume was 423 cm^3. Bigger lipomas tended to be more difficult to remove than smaller ones. Most tumors were located in the subcutaneous tissue. The 16 tumors under the deep fascia were almost equally likely to be intermuscular and intramuscular lipomas. These subfascial tumors tended to associate with more frequent surgical difficulty than the subcutaneous tumors. This was because all intramuscular subfascial lipomas were difficult cases. None of the intermuscular cases were difficult (Table 1).

CT and MRI were used equally frequently for imaging, but MRI was much more likely to be enhanced. In terms of imaging findings, the tumors that touched the underlying structures broadly were more common than those that touched these structures moderately or minimally. The broadly touching tumors were more likely to involve difficult surgery than tumors that touched these structures moderately or

Table 4 Final logistic regression analysis that included only the four selected factors

Variable	Estimate	Standard error	OR	95% CI		*p*-Value
(Intercept)	−3.79	0.91	2.27×10^{-2}	3.83×10^{-3}	0.134	0.00003
Subfascial intramuscular location	3.76	1.08	42.9	5.19	354	0.005
Broad touching of the underlying structures	3.38	0.95	29.3	4.52	189	0.004
In-flowing blood vessels	2.53	0.96	12.6	1.92	82.8	0.008
Unclear boundaries	3.2	1.41	24.5	1.55	386	0.02

CI confidence interval, *OR* odds ratio

minimally. Unilocular tumors were more common than multilocular tumors. Multilocular tumors tended to associate with more difficulty than unilocular tumors. A shaggy appearance, in-flowing blood vessels, unclear tumor boundaries, and tumor crossing the trunk midline were relatively rare findings but all seemed to associate strongly with difficult surgery. Normal fat tissue rarely intervened between the tumor and the underlying structure, but when it did, the tumor was easily extracted in all cases. An infiltration pattern was very rare, but both cases involved difficult extraction (Table 1).

Thus, at a purely descriptive level, a back of the neck/head and subfascial intramuscular location, broad touching of the underlying structures, multilocularity, a shaggy appearance, in-flowing blood vessels, unclear boundaries, crossing of the trunk midline, and an infiltration pattern appeared to promote difficult surgery. Fat between the tumor and underlying structures and a back of trunk location appeared to protect the patient from difficult surgery.

There were only two complications (seroma and hematoma); neither case involved difficult surgery.

Correlations between Patient/Tumor Characteristics and Difficult Surgery

Pearson correlation analyses with all variables listed in Table 1 were conducted. Ten variables correlated significantly with surgical difficulty.

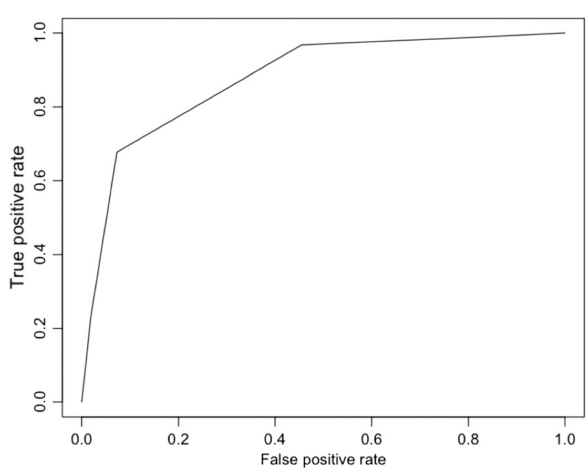

Fig. 8 ROC illustrating the diagnostic ability of the scoring system

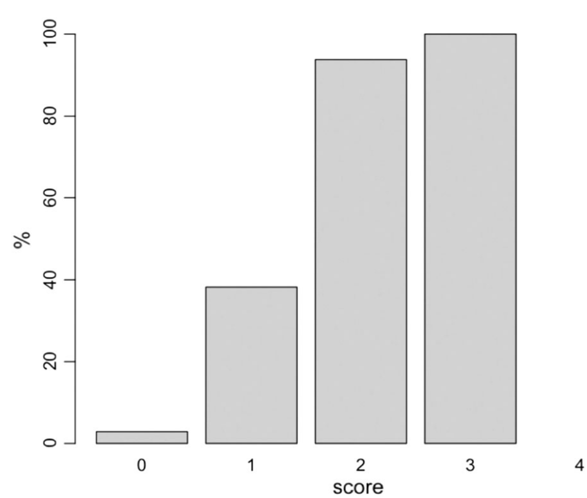

Fig. 9 Frequency with which tumors that scored 0–4 on our scoring system were difficult to resect. For example, 94% of tumors with a score of 2 were difficult cases

Eight correlated positively, namely operating time, back of the neck location, subfascial intramuscular location, broadly touching underlying structures, shaggy appearance, in-flowing blood vessels, crossing the trunk midline, and unclear boundaries. Two of the ten variables, namely back of the trunk location and minimally touching underlying structures, correlated negatively with surgical difficulty (Table 2).

Multivariate Regression Analysis to Determine Factors Predicting Difficult Surgery

All factors that were significant on univariate analysis were included in logistic regression analysis. Five significant associations were observed. A weak protective factor was a back of the trunk location (OR 0.87, 95% CI 0.008–0.92). Strong significant predictors of difficult surgery were a subfascial intramuscular location (OR 42.7, 95% CI 3.0–608.0), broad touching of underlying structures (OR 46.5, 95% CI 3.7–586.0), in-flowing blood vessels (OR 9.3, 95% CI 1.1–78.5), and unclear boundaries (OR 109.0, 95% CI 1.1–1110.0).

Construction of a Scoring System for Surgical Difficulty

After considering the five significant factors on multivariate regression analysis, four were used to generate the scoring system, namely subfascial intramuscular location, broad touching, in-flowing blood vessels, and unclear boundaries (Table 3). The back of the trunk variable was not included because it associated only weakly with surgical difficulty and this variable was difficult to use clinically as a scoring item. Each variable, if satisfied, was scored 1. Consequently, the scoring system ranged from 0 to 4. The results of the final logistic regression analysis that included the four selected factors are presented in Table 4.

Validation of the Scoring System

Tenfold cross-validation was performed to quantitatively assess the accuracy of the scoring system. The estimated accuracy was 82.4% (Cohen's kappa = 0.57), which is fair–good accuracy and sufficient for clinical practice.

To further evaluate the diagnostic ability of the scoring system and to identify a clinically useful cutoff point, ROC analysis was performed (Fig. 8). The calculated area under the curve (AUC) was 0.885. We set a cutoff of 2 on the basis of the AUC and clinical utility. Thus, if a lipoma has a score of $\geq$ 2, its resection is likely to be difficult. This cutoff point had an estimated sensitivity and specificity of 54.8% and 98.2%, respectively. Figure 9 shows the frequency with which the five scores (0–4) associated with difficult surgery: thus, while only 5% of the tumors with a score of 0 involved difficult surgery, 94% of the tumors with a score of 2 were difficult. There were no cases with a score of 4 in this study.

A supplementary analysis showed that, when all nine predictors identified by the correlation analyses were used, the estimated accuracy was 89.7% (kappa = 0.75) and the AUC was 0.933. Thus, the accuracy of the scoring system with only the four variables described above was not significantly impaired by not including the remaining five variables.

DISCUSSION

This study showed that, when lipoma resection difficulty was defined as difficulty separating some or all of the tumor from the surrounding tissue by hand and inability to extract the tumor in one piece, 36% of cases involved difficult surgery. We then sought to identify the factors that predict surgical difficulty. Before starting our research, our anecdotal experience suggested that tumors behind the neck, large tumors, tumors with an infiltration pattern, and multilocular tumors were difficult to remove. We also judged that it was more difficult to remove tumors on the back of the body. As a result, we divided the body into front and back regions. However, while our univariate analyses did show that the back of the neck and head associated with surgical difficulty, they also showed that back of the trunk associated with easy surgery. Moreover, on multiple logistic regression analysis, back of the neck and head did not predict surgical difficulty but back of the trunk was a mildly protective factor. Our multivariate analyses also showed that large tumors, tumors with an infiltrative pattern, and multilocularity did not predict surgical difficulty, which was also contrary to our expectations.

The significant predictors of difficult lipoma resection were subfascial intramuscular tumors, tumors that touched the underlying structures broadly, tumors with in-flowing blood vessels, and tumors with unclear boundaries. These associations make clinical sense: subfascial intramuscular tumors are difficult to extract per se; tumors that touch the underlying structures broadly are likely to adhere tightly to the surrounding tissue, thus complicating dissection; tumors with in-flowing blood vessels can lead to increased intraoperative bleeding; and unclear tumor boundaries make the peeling procedure more challenging.

Signorini and Campiglio suggested that some lipomas develop as a result of blunt trauma-induced local inflammation, which in turn induces adipocyte neotransformation [9]. Thus, there may be a link between a cascade of trauma, inflammation, and adhesions and surgical difficulty. This is supported by several other of our descriptive and univariate findings, namely surgical difficulty also associated with (i) a shaggy tumor appearance, (ii) tumor location on the back of the neck and head, (iii) tumor crossing the trunk midline, and (iv) absence of fat between the tumor and underlying structures. A shaggy tumor appearance is a characteristic sign of inflammation, while the back of the neck and head are sites where minor trauma often occurs, especially at bedtime in the supine position. While none of our patients had a clear history of trauma, there are cases in the literature where huge lipomas arose after microtrauma [10, 11]. The association with trunk midline crossing may reflect the many ligamentous tissues in the midline of the trunk, which are particularly prone to forming adhesions. Finally, the absence of normal fat between the tumor and underlying structures is also an inflammation- and adhesion-prone setting, similar to tumors that broadly touch the underlying structures.

Our scoring system was shown to predict surgical difficulty in lipoma operation with fair–good accuracy. This scoring system can be useful in several ways. First, the operator would be prepared for surgical difficulty and a longer operative time and could therefore select general anesthesia. Second, the skin incision could be made longer right at the beginning, thus shortening the operation time. Third, since longer operative times can associate with postoperative complications, our scoring system could help improve patient outcomes. Fourth, our scoring system could be particularly useful in settings where preoperative imaging is not routinely conducted for lipoma resection but the surgeon suspects the surgery could be difficult.

This study has some limitations. First, multiple surgeons with differing levels of experience conducted the operations. Since the judgment of surgical difficulty seems to depend on the skill and experience of the operator, this variable is not completely objective. Second, the study population was relatively small ($n = 86$) compared with a large number of surgeons ($n = 34$). Since our hospital is an educational institution, many young doctors have the opportunity to operate, and lipoma removal is a relatively common operation, therefore many surgeons were inevitably involved in this study. However, experienced surgeons (six board-certified plastic surgeons) were present as an instructor in all operations. Surgeons did not perform surgeries solely in the operating theater. Third, the study was based on retrospective medical chart review, which can be prone to selection and information bias. Fourth, our facility is a tertiary care center, which means many of the patients were referred to us and may therefore include relatively difficult cases. This is supported by the relatively high rate of surgical difficulty in our cohort (36%) and the fact that 19% of the resected lipomas had deep locations: it has been reported that only 1% of lipomas have such deep locations [3]. The feasibility of our scoring system in other surgical settings should be evaluated. Finally, we did not observe body-site-specific associations with lipoma resection difficulty. This may partly reflect the relatively imprecise way we categorized tumor sites on the trunk (back and front of trunk). Further studies looking at more specific trunk-site associations may provide additional predictive variables than could enhance the accuracy of our scoring system. A prospective study with a larger sample size generated by recruiting patients from other centers will be needed to validate the objectivity of the scoring system.

CONCLUSIONS

We developed a scoring system that predicted the difficulty of lipoma extraction with fair–-good accuracy. The system includes four factors, namely subfascial intramuscular location, broad touching of the tumor with underlying structures, in-flowing blood vessels, and unclear boundaries. Further studies validating this scoring system in independent patient cohorts must be conducted before it can be used in clinical settings.

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Author Contributions. Shimpei Ono designed the study; Goh Akiyama enrolled the patients; Goh Akiyama and Shimpei Ono analyzed the data; Tetsuro Sekine performed image inspection analysis; Satoshi Usami performed statistical analysis; Rei Ogawa supervised the study; Goh Akiyama and Shimpei Ono wrote the manuscript.

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Compliance with Ethics Guidelines. This study was approved by the ethics committee of Nippon Medical School, Japan (No. B-2020-210). It was performed in accordance with the Helsinki Declaration of 1964 and its later amendments. All patients gave written informed consent.

Data Availability. The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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