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Survey of sarcoma surgery principles among orthopaedic oncologists

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ABSTRACT

Background: Surgical principles and techniques used during primary sarcoma excision focus on acquiring negative margins, reducing the risk of local recurrence, and minimizing contamination. These principles and techniques within orthopaedic oncology are not well documented in the literature. No standardized surgical hand-off or approach to education across disciplines on orthopaedic oncology principles and techniques has been published. Currently, education on intraoperative approaches is passed down by oral tradition.

Objectives: Our objective was to survey members of the Musculoskeletal Tumor Society (MSTS) to identify their core principles and practices in orthopaedic oncology. We aimed to 1) provide descriptive analyses of surgeon technique patterns; 2) determine correlations between individual practice patterns; and 3) identify distinct clusters of surgeons on the basis of common practice tendencies.

Methods: A web-based, 16-question survey regarding orthopaedic oncology intraoperative principles and techniques was distributed online to all 349 members of the MSTS in 2021. There were 137 (39%) unique respondents, all of whom completed the entire survey. The 16 survey questions were grouped into 4 key aspects of sarcoma excision: pre-incision, exposure of the mass, delivery of the mass, and closure. The questions inquired about respondent preference on draping, back table setup, instrument use, and intraoperative decision making. These questions were selected on the basis of existing reports, as well as the senior author's experience. We analyzed the responses using 3 methods: 1) descriptive statistics, 2) correlations between question responses, and 3) clustering analysis. We used an artificial intelligence–based clustering algorithm to cluster respondents according to their practice patterns. The results of our correlation analyses are reported as Spearman's rho (ρ) correlation coefficients.

Results: Most respondents (mean, 71%; standard deviation, 22%) reported using the described surgical techniques "most of the time" or "in all cases." A strong positive correlation was found between respondents who answered "yes" to both of the following questions: "Do you change your surgical gloves after passing off the tumor specimen?" and "Does your entire surgical team change their gloves after passing off the tumor specimen?" ($\rho = 0.88$). A moderate positive correlation was found between those who answered "yes" to both of the following questions: "Do you change your surgical gloves after passing off the tumor specimen (i.e., prior to closure)?" and "Do you use new and/or unused surgical instruments for the final closure?" ($\rho = 0.60$). The cluster analysis identified 3 distinct clusters of respondents. The conservative technique cluster (N = 42) was more likely to answer "yes" to 9 of the 10 questions regarding incision management, consultant team communication, gloving, and instrument use, whereas the permissive technique cluster (N = 41) was more likely to answer "no" to questions regarding gloving, draping, and instrument use.

Conclusions: Our findings indicate that most respondents perform the surveyed techniques, and there is homogeneity in the practice patterns of members of the MSTS; however, we identified distinct clusters of respondents who were significantly more likely to perform certain techniques. These results support establishing a standardized set of intraoperative techniques and formal surgical education regarding intraoperative principles and techniques in orthopaedic oncology.

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1. Introduction

Surgical techniques used by orthopaedic oncologists in the treatment of sarcomas have not been well described. These techniques focus on acquiring negative margins and reducing the risk of local recurrence and iatrogenic metastases, as well as limiting contamination [1–4]. Examples of such techniques include changing of gloves during tumor excision, separating tumor-contaminated instruments from unused instruments, and managing tumor violation [1]. Previous prospective studies have demonstrated evidence of tumor cells on gloves and instruments used during excision [1,5]. A prospective study by Yu et al. [6] also found that higher-stage tumors were associated with more tumor cells on instruments and gloves on cytopathologic analysis. Although evidence supports the use of these techniques because of the presence of cells, there have been no rigorous studies designed to determine the efficacy of these techniques in reduction of local recurrence or iatrogenic metastases. Because many of the techniques are taught during fellowship and can be specific to institutions or the preferences of the attending surgeon, variations in fellowship training may influence the surgical principles ultimately used by surgeons.

Variation in surgical techniques has been described in the orthopaedic fields of spine surgery [7], joint arthroplasty [8], sports surgery [9], and hand surgery [10]. However, we are aware of no studies on the variation in intraoperative surgical techniques among orthopaedic oncologists. Currently, no standardized education on orthopaedic oncology principles and techniques exists. Rather, knowledge and methods are passed down by oral tradition. Therefore, we sought to identify core surgical oncologic practices in the field of orthopaedic oncology and to assess variation in these surgical practices among fellowship-trained orthopaedic oncologists.

Our objective was to survey members of the Musculoskeletal Tumor Society (MSTS) to identify their core principles and practices in orthopaedic oncology. We aimed to 1) provide descriptive analyses of surgeon technique patterns; 2) determine correlations between individual practice patterns, and 3) identify distinct clusters of surgeons on the basis of common practice tendencies. We hypothesized that most MSTS members would share similar core surgical techniques and philosophies.

2. Materials and methods

2.1. Survey design and administration

A survey was administered to all 349 orthopaedic oncologists who were members of the MSTS during 2021: 194 active, 82 candidate, 26 emeritus, 25 resident, 16 associate, and 6 affiliate members. All active, associate, and candidate members are fellowship-trained in orthopaedic oncology. The survey was administered using internet-based software (Google Forms; Google LLC, Mountain View, CA). The MSTS electronic mailing list was used to e-mail a survey link to all MSTS members. Two survey emails were sent: one at the opening of the survey period and another 48 h before closure of the survey. Members responded to the survey anonymously. No sensitive or identifying information was obtained from members; thus, no institutional review board review was required. Overall, 137 of 349 MSTS members completed the survey (39% response rate). All respondents were unique and completed the survey in its entirety.

Respondents were asked to answer the survey questions in terms of their practices excising a sarcoma. The survey comprised 16 questions grouped into 4 key aspects of sarcoma excision: pre-incision, exposure of the mass, delivery of the mass, and closure. Questions assessed these topics on the basis of the respondent's current practice. Of the 16 questions, 13 had the following ordinal responses: yes (performed in >90% of cases), most of the time (performed in >50% of cases), sometimes (performed in <50% of cases), and no (not performed in any case, <10%). "Not performed in any case" was defined as <10% to account for extraordinary cases that may have led respondents to use a technique in the past that they do not typically use. The 3 remaining questions were multiple choice. The survey questions and response choices are provided in Table 1.

2.2. Statistical analysis

Our statistical analysis consisted of descriptive statistics, correlations between question responses, and clustering analysis. Correlations between each pair of questions were assessed using the Spearman's rank-order correlation method [11,12]. The results of these correlation analyses are reported as Spearman's rho correlation coefficients (ρ). Per convention, $\rho < 0.3$ indicates weak correlation, 0.3–0.49 is modest, 0.5–0.69 is moderate, 0.7–0.89 is strong, and ≥0.9 is very strong [13].

An artificial intelligence–based hierarchical clustering technique was used to identify intrinsic clusters in the dataset using an "unsupervised" method. Compared with "supervised" clustering, which groups observations according to a user-provided endpoint, unsupervised clustering clusters according to the intrinsic heterogeneity of the dataset, enabling the discovery of complex groupings. A Hopkins statistic of 0.73 indicated the survey responses had sufficient heterogeneity for effective clustering [14]. Using the "silhouette" and "gap statistic" methods [15], we determined that the optimal number of clusters existing within the dataset was 3, representing 3 distinct groups of respondents according to their collective survey responses (Supplemental Digital Content 1). We compared the 3 clusters using Kruskal-Wallis tests to determine significant differences between clusters based on how respondents within each cluster answered the survey questions relative to respondents in the other clusters. We "characterized" each cluster according to the collective survey responses of its members relative to the other clusters. The descriptive statistics and correlation coefficients represent analyses performed on the individual question level. The hierarchical cluster analysis enabled the identification of 3 unique "patterns" of practice using all questions within the survey for the cluster algorithm. Statistical significance was set at $p < 0.05$. All statistical analyses were performed using R, version 3.6.3, software (R Foundation for Statistical Computing).

3. Results

3.1. Descriptive analyses

Most respondents (mean, 71%; standard deviation, 22%) reported using the described surgical techniques "most of the time" or "in all cases." For 9 of 13 questions, most responses were "yes", indicating that the respondent used the given technique all of the time (Table 1). In particular, 72% (N = 97) responded "yes" to the question, "Do you orient your specimen on a physically separate, sterile site from the surgical site/primary surgical table?"; 71% (N = 96) responded "yes" to the question, "Do you change your surgical gloves after passing off the tumor specimen (i.e., prior to closure)?"; and 69% (N = 94) responded "yes" to the question, "Prior to final sterile preparation, do you complete a non-sterile preparation of the operative site (with chlorhexidine scrub, alcohol preparation, wet preparation, etc.)?" (Table 1).

Greater variability in responses was found for the 7 questions for which most respondents did not answer "yes" (Table 1). Seventy-seven percent (N = 105) of respondents answered "sometimes" or "no" to the question, "If there is > 1 planned surgical site: Do you perform a new prep and drape?"; 38% (N = 52) answered "sometimes" or "no" to the question, "If you physically isolate the instruments, do you place the handles in the same direction?"; and 46% (N = 62) answered "sometimes" or "no" to the question, "Do you use new and/or unused surgical instruments for the final closure?" (Table 1).

For the question, "Following wide excision of a sarcoma of the thigh, the surgical team elects to leave a postoperative drain exiting in line to the incision. What distance from the end of the incision do you have the drain exit the skin? (<1 cm, 1–2 cm, >2 cm)", 73% (N = 100) of

Table 1
Questions and responses to a 2021 survey of 137 musculoskeletal tumor society members on principles and practices in the setting of excision of a sarcoma.

Survey	Responses[a], N (%)				
Ordinal Questions	Yes	Most of the time	Sometimes	No	N/A
Prior to final sterile preparation, do you complete a non-sterile preparation of the operative site (with chlorhexidine scrub, alcohol preparation, wet preparation, etc.)?	94 (69)	10 (7.3)	13 (10)	19 (14)	0 (0)
If there is > 1 planned surgical site: Do you sterilely cover separate sites until you are ready to transition to the secondary site?	74 (54)	41 (30)	16 (12)	5 (3.6)	0 (0)
If there is > 1 planned surgical site: Do you perform a new prep and drape?	15 (11)	16 (12)	67 (49)	38 (28)	0 (0)
Do you set-up a separate surgical table for secondary teams (i.e., plastic, vascular) if the procedure by the other team is within the same surgical field?	92 (68)	13 (10)	21 (15)	10 (7.3)	0 (0)
Do you widely ellipse the previous incision/biopsy?	92 (68)	31 (23)	13 (10)	0 (0)	0 (0)
Do you physically isolate the surgical instruments that manipulate tumor/ tumor bed away from the rest of the "clean" surgical instruments (i.e., within a separate basin, distinct location, etc.)?	76 (56)	27 (20)	6 (4.4)	26 (19)	0 (0)
If you physically isolate the instruments, do you place the handles in the same direction?	22 (16)	17 (13)	9 (6.6)	43 (32)	45 (33)
Do you change your surgical gloves after passing off the tumor specimen (i.e., prior to closure)?	96 (71)	19 (14)	8 (5.8)	13 (10)	0 (0)
Does your entire surgical team change their surgical gloves after passing off of the tumor specimen?	84 (62)	26 (19)	12 (8.8)	14 (10)	0 (0)
Do you orient your specimen on a physically separate, sterile site from the surgical site/primary surgical table?	98 (72)	16 (12)	4 (2.9)	18 (13)	0 (0)
Do you use new and/or unused surgical instruments for the final closure?	53 (39)	21 (15)	27 (20)	35 (26)	0 (0)
When plastic surgery performs the wound closure, do they follow oncologic principles?	58 (43)	48 (35)	21 (15)	9 (6.6)	0 (0)
When plastic surgery performs the wound closure, do you counsel them to observe oncologic principles?	93 (68)	19 (14)	15 (11)	9 (6.6)	0 (0)
Multiple-Choice Questions	**Answer Selection: N (%)**				
Following wide excision of a sarcoma of the thigh, the surgical team elects to leave a postoperative drain exiting in line to the incision. What distance from the end of the incision do you have the drain exit the skin?	<1 cm: 30 (5)	1–2 cm: 100 (73)	>2 cm: 7 (22)		
A patient undergoes wide excision of a sarcoma of the thigh. The wound cannot be primarily closed and definitive reconstruction must be delayed. You have concerns regarding the adequacy of your final margins. Do you proceed with:	Wound vacuum-assisted closure: 121 (89)	Wet-to-dry dressing: 10 (7)	Other: 6 (4)		
If an inadvertent tumor violation occurs during dissection, how is this managed? (Please check all that apply)	Violation closed with additional adjacent tissue resected and attached to primary as best able: 60 (44)	Violation closed, clips/marker placed on adjacent tissue for localization and consideration of radiotherapy postoperatively: 23 (17)	Violation closed with additional adjacent tissue resected and sent as a frozen until negative margin achieved where able: 27 (20)	Violation closed with additional adjacent tissue resected and oriented and sent as an additional permanent section: 27 (20)	

[a] "Yes" means performed in all cases (>90%); "most of the time" means performed in >50% of cases, but not all cases; "sometimes" means performed <50% of cases, but not 0 cases; and "no" means not performed in any case (<10%).

respondents selected "1–2 cm", 22% (N = 7) answered ">2 cm", and 5% (N = 30) answered "<1 cm" (Table 1). In response to the question, "A patient undergoes wide excision of a sarcoma of the thigh. The wound cannot be primarily closed and definitive reconstruction must be delayed. You have concerns regarding the adequacy of your final margins. Do you proceed with:" 89% (N = 121) of respondents answered "wound vacuum-assisted closure", 7% (N = 10) answered "wet-to-dry dressing," and 4% (N = 6) answered "other" (Table 1). Finally, respondents were asked, "If an inadvertent tumor violation occurs during dissection, how is this managed?" This question was answered by checking all answer choices which applied to the respondent's practice patterns. Forty-five respondents (33%) chose to close the violation, resect additional adjacent tissue, and attach it to the main tumor specimen as best able. Twenty respondents (15%) chose to close the violation and to resect additional tissue as permanent sections for margin purposes. Descriptive analyses for the remainder of the questions are detailed in Table 1.

3.2. Correlations between questions

A strong positive correlation was found between those who answered "yes" to both of the following questions: "Do you change your surgical gloves after passing off the tumor specimen (i.e., prior to closure)?" and "Does your entire surgical team change their surgical gloves after passing off of the tumor specimen?" (ρ = 0.88; Table 2). A moderate positive correlation was found between those who answered "yes" to

Table 2
Correlation matrix between each pair of 13 ordinal questions in a 2021 survey of 137 musculoskeletal tumor society members on principles and practices in orthopaedic Oncology*.

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13
Q1		0.21	-	-	-	-	-	-	0.19	-	-	0.21	0.25
Q2			-	0.30	-	-	-	-	-	0.23	0.21	-	0.24
Q3				-	-	-	-	0.29	0.25	-	0.19	-	-
Q4					0.28	0.31	0.24	0.32	0.26	0.22	0.27	-	-
Q5						0.37	0.21	0.17	-	-	0.19	-	-
Q6							-	0.47	0.49	0.21	0.46	-	-
Q7								0.28	0.22	0.25	0.26	-	-
Q8									0.88	0.40	0.60	-	-
Q9										0.36	0.63	-	-
Q10											0.26	-	-
Q11												0.35	-
Q12													0.42
Q13													

*Decimal values indicate Spearman's coefficient values that were significant. Nonsignificant correlation coefficients are represented with a dash. Only questions with ordinal response choices were included in the correlation analysis.
Q1: Prior to final sterile preparation, do you complete a non-sterile preparation of the operative site (with chlorhexidine scrub, alcohol preparation, wet preparation, etc)?
Q2: If there is >1 planned surgical site: Do you sterilely cover separate sites until you are ready to transition to the secondary site?
Q3: If there is >1 planned surgical site: Do you perform a new prep and drape?
Q4: Do you set-up a separate surgical table for secondary teams (i.e., plastic, vascular) if the procedure by the other team is within the same surgical field?
Q5: Do you widely ellipse the previous incision/biopsy?
Q6: Do you physically isolate the surgical instruments that manipulate tumor/tumor bed away from the rest of the "clean" surgical instruments (i.e., within a separate basin, distinct location, etc.)?
Q7: If you physically isolate the instruments, do you place the handles in the same direction?
Q8: Do you change your surgical gloves after passing off the tumor specimen (i.e., prior to closure)?
Q9: Does your entire surgical team change their surgical gloves after passing off of the tumor specimen?
Q10: Do you orient your specimen on a physically separate, sterile site from the surgical site/primary surgical table?
Q11: Do you use new and/or unused surgical instruments for the final closure?
Q12: When plastic surgery performs the wound closure, do they follow oncologic principles?
Q13: When plastic surgery performs the wound closure, do you counsel them to observe oncologic principles?

both of the following questions: “Do you change your surgical gloves after passing off the tumor specimen (i.e., prior to closure)?” and “Do you use new and/or unused surgical instruments for the final closure?” (ρ = 0.60; Table 2). A moderate positive correlation was found between those who answered “yes” to the question, “Does your entire surgical team change their surgical gloves after passing off of the tumor specimen?” and “Do you use new and/or unused surgical instruments for the final closure?” (ρ = 0.63; Table 2). Table 2 shows the correlations between each pair of questions in the survey.

3.3. Cluster analysis

The hierarchical clustering algorithm grouped the respondents into 3 distinct clusters according to responses to all 16 questions. For visual interpretation, Fig. 1 displays the 3 clusters mapped onto 2 dimensions using a principal component analysis dimensionality reduction algorithm [16]. The 3 clusters differed significantly by their responses to 11 questions. The clustering algorithm separated the 3 clusters, termed the “conservative technique” cluster (N = 42), the “permissive technique” cluster (N = 41), and the “miscellaneous” cluster (N = 54), primarily according to responses to these 11 questions.

Of these 11 questions, 10 had ordinal responses of “yes,” “most of the time,” “sometimes,” and “no,” and 1 question had categorical responses. Compared with the other clusters, respondents in the conservative technique cluster were the most likely to answer “yes” to 9 of the 10 ordinal questions ($p < 0.05$ for all).

The permissive technique cluster was distinguished on the basis of responses to the questions focused on management of gloving, draping, and instrument use. Compared with the other clusters, respondents in the permissive technique cluster were most likely to answer “no” to the following questions: “If there is > 1 planned surgical site: Do you perform a new prep and drape?“; “If you physically isolate the instruments, do you place the handles in the same direction?“; “Do you change your surgical gloves after passing off the tumor specimen (i.e., prior to closure)?“; and “Does your entire surgical team change their surgical gloves after passing off of the tumor specimen?” ($p < 0.05$ for all).

The miscellaneous cluster comprised the remaining respondents. The members in this cluster were most likely to answer “no” to the following questions: “Do you set-up a separate surgical table for secondary teams (i.e., plastic, vascular) if the procedure by the other team is within the same surgical field?“; “Do you widely ellipse the previous incision/biopsy?“; “Do you physically isolate the surgical instruments that manipulate tumor/tumor bed away from the rest of the “clean” surgical instruments (i.e., within a separate basin, distinct location, etc.)?“; “Do you orient your specimen on a physically separate, sterile site from the surgical site/primary surgical table?“; “Do you use new and/or unused surgical instruments for the final closure?“; and “When plastic surgery performs the wound closure, do they follow oncologic principles?” ($p < 0.05$ for all). Respondents in the miscellaneous cluster were more likely to leave a longer drain (>2 cm) compared with respondents in the other clusters ($p < 0.05$).

4. Discussion

No universally accepted formal standardized curriculum exists on intraoperative principles and techniques in the treatment of primary sarcomas in orthopaedic oncology. The oral dissemination and teaching of intraoperative techniques during orthopaedic oncology fellowship can vary according to many variables, including attending surgeon preference, fellowship operative exposure, and/or institutional tradition. As such, the aim of our investigation was to characterize the most common intraoperative practices of MSTS members and to identify correlations in current practice patterns. Nine techniques were used by most respondents all or most of the time, which we designated as “core principles”: 1) preparation of the operative site; 2) separate draping of multiple surgical sites; 3) separate surgical tables and tools for separate surgical teams; 4) previous incision/biopsy tract excision and en bloc removal with tumor; 5) isolation of contaminated instruments; 6) changing of gloves after tumor delivery; 7) tumor orientation away from the main surgical field; 8) use of new instruments after tumor delivery; and 9) distance of drain placement from incision. Our survey results demonstrate homogeneity in the use of intraoperative principles and techniques among MSTS members, despite limited literature and no standardized education on surgical techniques for sarcoma excision. These results may serve as a foundation for the standardization of intraoperative principles and techniques in orthopaedic oncology, as well as a formal educational course for surgical residents and fellows.

Up to 91% of respondents used the 9 core principles and techniques included in our survey most or all the time. These core techniques focus

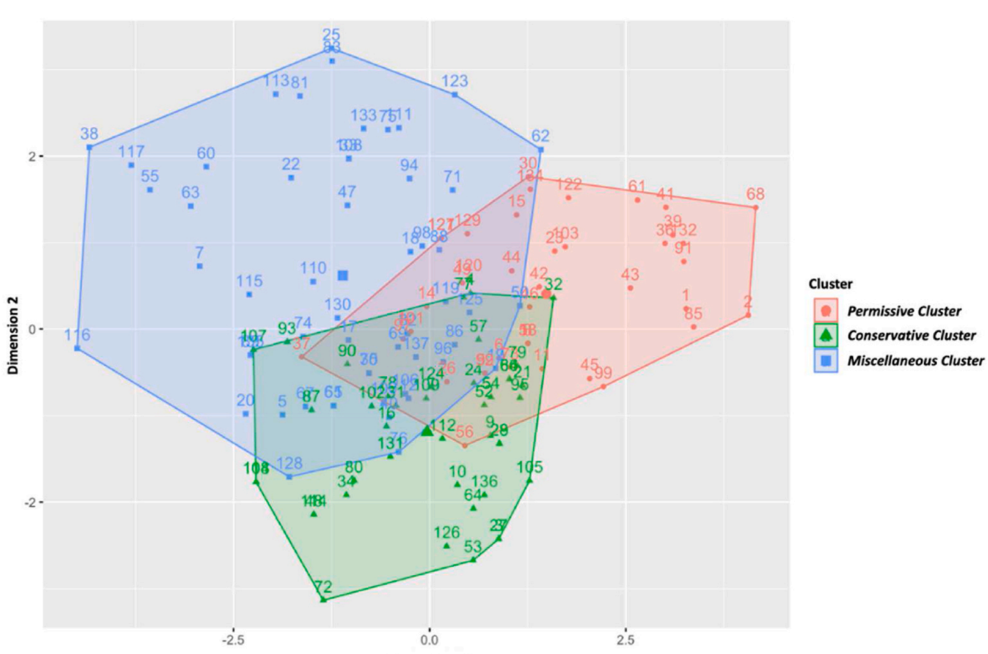

Fig. 1. Using a hierarchical clustering algorithm, we grouped the 137 Musculoskeletal Tumor Society member respondents into 3 distinct clusters according to all 16 survey question responses. For visualization of cluster distinction, the 3 clusters, termed “conservative technique” cluster (N = 42), the “permissive technique” cluster (N = 41), and the “miscellaneous” cluster (N = 54), are mapped onto 2 dimensions (X-axis and Y-axis) using a principal component analysis dimensionality reduction algorithm. The numbers plotted on the graph indicate each unique survey respondent.

on obtaining negative margins, reducing the risk of local recurrence, and limiting contamination by preparing multiple surgical tables, excising contaminated tissue, changing gloves after sarcoma removal, isolating contaminated instruments, and communicating between consultant teams. In 1907, Ryall [17] published a landmark study on local recurrence and tumor implantation, in which he described cases of recurrence in carcinomas. He hypothesized that these recurrences may be secondary to tumor disruption and cell implantation. Tumor implantation can occur because of spillage of cells after breaching the tumor capsule, hemorrhage, or by inadvertent, iatrogenic contamination. In 1996, Curran et al. [1] described 15 patients who underwent dissections and excisions for carcinomas of the head and neck. After removal of the specimens, the authors washed their gloves and instruments separately in solution and found tumor cells in the washing solution in 87% (13/15) of the cohort. Findings like these led surgical oncologists to implement techniques such as changing gloves, gowns, and instruments after removal of tumors. Iatrogenic tumor implantation has also been described in reports of metastases within or near incision sites, biopsy sites, or at skin and bone graft harvest sites. For example, Ebelin et al. [18] reported an osteosarcoma arising at the harvest site of an iliac crest autograft for treatment of a presumed benign metacarpal tumor. Prevention of these complications is emphasized during fellowship, which may explain why most MSTS members who routinely use these techniques report excising previous incisions and biopsy tracts and using new instruments after manipulation of the tumor.

In our survey, most respondents reported always counseling their secondary teams to observe oncologic principles while completing their portion of a surgery. However, fewer respondents reported that secondary teams always follow these principles. Most respondents reported that their secondary teams followed the principles 10%–90% of the time, rather than all of the time. We hypothesize that this discrepancy may be attributable to secondary teams being unaware of which oncologic principles are important and, thus, which ones they should follow. Many respondents reported having taken the initiative to educate and instruct the consultant surgery teams, including vascular surgery and plastic surgery teams, on intraoperative orthopaedic oncology principles and techniques. However, opportunities for improvement exist. Incorporating education on the rationale for these techniques into the curricula of general surgery, plastic surgery, and orthopaedic surgery residencies has the potential to establish “best practices” in orthopaedic oncology. Another possibility may be using the time-out process to discuss the oncology principles and their benefits when multiple teams are involved in an operative case. Increasing the exposure to these principles and techniques early in surgical residency and/or fellowship training may emphasize the importance of these core principles, ultimately increasing their use in surgical oncology cases.

We found several correlations between individual practice patterns. First, respondents who reported changing their gloves after tumor delivery were likely to have their whole team change gloves and use new instruments for closure. Second, those who changed their gloves after tumor delivery were likely to manipulate the resected tumor away from the surgical field at a different table. Third, those who separated their tools were also more likely to change their gloves and have the team do so and to use new instruments for closure. We hypothesize that these correlations are associated with surgeon concerns for contamination of unaffected tissues and surfaces with tumor cells. Finally, our data show a positive correlation between surgeons counseling intraoperative teams to follow oncologic principles and those teams, in turn, following the principles. This finding highlights the importance of multidisciplinary team communication and education to increase the use of these oncologic techniques to reduce contamination and complications. Currently, no literature exists within orthopaedic surgery or other subspecialities on these fundamental oncologic techniques and principles. A standardized resource on orthopaedic oncology principles may further the education and communication among surgical teams.

Clustering analysis revealed a cluster of respondents who performed most of the techniques assessed in the survey, as well as a second cluster who were less likely to change their drapes, gloves, or instruments after sarcoma removal. This cluster analysis has 2 important implications. First, the practice of passing down surgical techniques via oral tradition has resulted in groups of surgeons with fairly homogenous techniques. Because most practicing orthopaedic oncologists in the United States are MSTS members, the survey responses may represent the intraoperative practice patterns of most orthopaedic oncology care in the country. Second, the difference between the conservative and permissive clusters regarding draping and gloving practices suggests an opportunity to further standardize common practices via formal documentation of the standard operative surgical techniques and principles in musculoskeletal oncology care. Future investigations may consider including the location of fellowship training within a clustering algorithm. These data could help determine the degree to which training and institutional preferences affect practice patterns.

Our study has several potential limitations. First, we did not give respondents an opportunity to describe other intraoperative techniques they use and thus may be biased in our reporting of techniques and principles. Second, we did not assess differences in outcomes or complications between study respondents who use these techniques versus those who do not; therefore, we are unable to report how differences in surgeon practices affect patient outcomes. Third, although our response rate of 39% is similar to that of other survey studies, there is a possibility of selection bias in the MSTS members who chose to respond to the survey. Finally, we did not attempt to confirm receipt of the survey by MSTS members on the electronic mailing list, which may also have contributed to selection bias.

5. Conclusions

Orthopaedic oncology intraoperative techniques and principles for the treatment of sarcomas have not been well described, nor have they been taught outside of fellowship in a standardized fashion. Despite this, most fellowship-trained orthopaedic oncologists who responded to our survey use specific principles and techniques and educate their multidisciplinary teams on these principles. To our knowledge, the present study is the first to assess surgical practice patterns and correlations of practice patterns of orthopaedic oncologists. We found homogeneity in the practice patterns of most of the orthopaedic oncology surgeons who responded to our survey. As the oncology patient population grows and orthopaedic oncologic care continues to become more multidisciplinary, it will be beneficial to establish formal education for standard-of-care intraoperative surgical oncology techniques during surgical residency and fellowship for those specialties involved in sarcoma surgical care.

CRediT author statement

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Declarations of interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.suronc.2022.101782.

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