Intraoperative differentiation during soft tissue sarcoma excision using near infrared autofluorescence spectroscopy

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Abstract:

Background: Soft tissue sarcomas (STS) are a rare and heterogeneous group of malignant tumors that arise from mesenchymal tissues. The mainstay of local treatment is to completely excise the tumor with a wide margin of normal tissue to ensure that no malignant cells remain within the tumor bed. Incomplete resection of tumors has been shown to be a primary cause of local recurrence, which can lead to increases in patient morbidity and healthcare costs. Current intraoperative and postoperative assessment methods are limited in time and sampling errors which highlights the need for an improved approach for preventing incomplete resections.

In terms of current research methods for tumor margin evaluation, optical techniques have been a popular area of study due to their potential to provide automated, and non-destructive assessment of tissue health. Autofluorescence spectroscopy, in particular, is a technique for measuring the intrinsic light emissions from natural biological fluorophores that are excited by a light source. It does not require the use of any toxic exogenous contrast agents, and may provide a quick and cost-effective method for identifying the presence of abnormal tissue within the tumor bed.

Purpose: The primary purpose of this study is to investigate the hypothesis that intraoperative near-infrared autofluorescence spectroscopy can be used to differentiate STS from the surrounding normal tissue. This would lead to the development of a surgical guidance tool that can report the locations of suspicious tissues for immediate excision, which would help ensure the complete removal of the tumor with clear margins in a single procedure.

Patients and Methods: Intraoperative *in vivo* data was collected from amongst 30 patients screened for STS excisional surgery. After each tumor was completely excised, a sterilized fiberoptic probe connected to a mobile spectroscopy system was used to measure various tissues within the tumor bed, which included control healthy tissues such as muscle and fat. Afterwards, a small incision was made on the excised tumor and measurements were made from within the tumor's interior. Data was used to generate a model based on multinomial linear regression, which was then validated using a leave-one-patient-out technique. STS subtype was confirmed via post-operative histopathology.

Results: Preliminary results demonstrate that the algorithm's sensitivity and specificity for identifying the presence of STS from normal tissue was 82% and 83% respectively. When well-differentiated liposarcomas are excluded from the model due to their pathological similarities to normal fat, specificity increased to 93%. In addition, it is observed that normal muscle exhibits a much stronger autofluorescence signal compared to normal fat or any STS subtype.

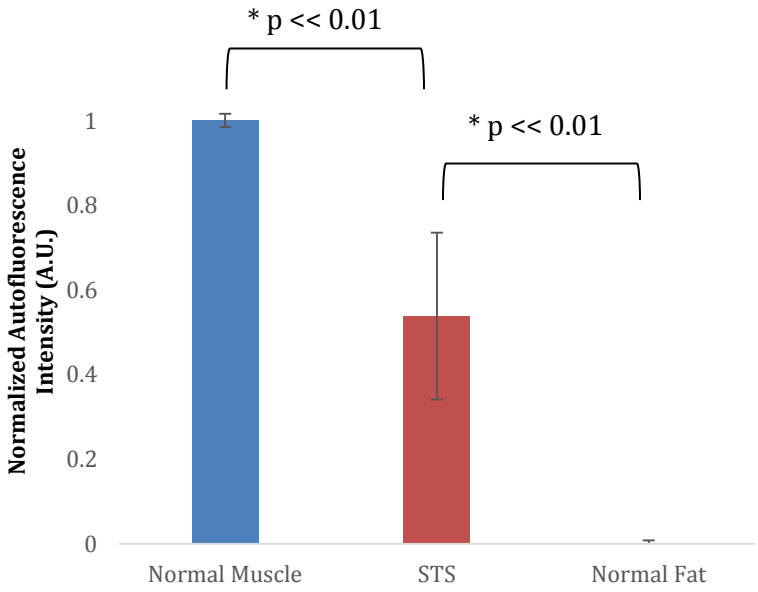

Fig 1: Normalized fluorescence area under the curve distribution for normal muscle, STS, and normal fat. Error bars indicate 95% confidence interval. Significant differences are marked with an asterisk.

Conclusions: Despite the heterogeneity of STS subtypes, we have demonstrated that it is possible to detect the presence of STS from normal muscle and fat based on near-infrared autofluorescence alone. These findings can be utilized in the future for real-time discrimination of STS during surgical resections.