Industry Day Theme # SMT

SLIC-Supervoxels Based Sub-segmentation of Different Pathological Tissues within Tumor using Multi-parametric MRI Data

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Introduction: Neoadjuvant Chemotherapy (NACT) is an anti-cancer therapy. NACT prevents rapid cell division, destructs cancerous cell and induces necrosis in tumor. Thus amount of necrosis is a marker of anti-cancer treatment response. Histopathological examination (HPE) is the gold standard for measuring necrosis in resected tumor but possible only after surgery. This project was intended to develop a non-invasive, imaging based robust method to delineate, visualize and quantify the proportions of necrosis and viable tissue present within the tumor in the course of NACT.

Materials and Methods:

Subjects: 30 patients (N=30;M:F=24:6;Age=17.6±2.7years) with Osteosarcoma.

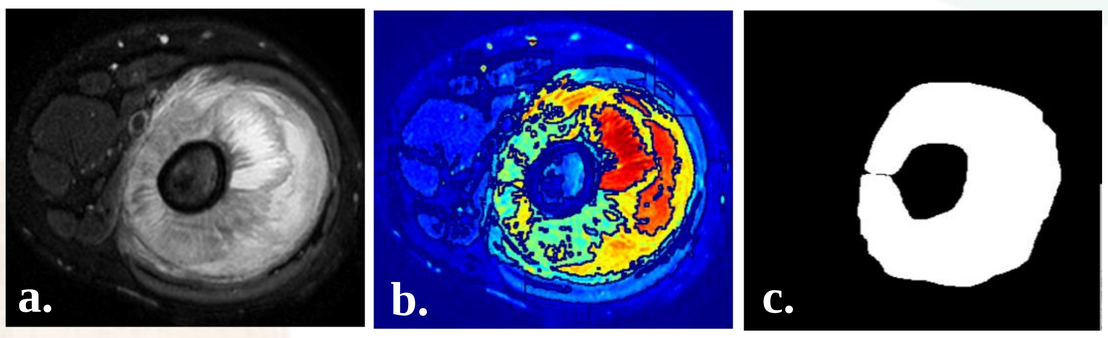
MRI data: 1.5T Philips-Achieva MRI-scanner was used.

i) Structural T2-weighted image (T2W).
ii) Functional Diffusion weighted image (DWI).
iii) Apparent Diffusion Coefficient (ADC) map.

Image Analysis:

a) MR images were pre-processed for noise reduction and grey-level normalization.
b) Simple-Linear-Iterative-Clustering-Supervoxels (SLICs) method was used to generate supervoxels by clustering voxels of similar intensity in close proximity.
c) Otsu-Multi-thresholding was used to combine the supervoxels of higher mean intensities to generate segmentation mask.
d) Proposed **SLICs+MTh** method was applied at baseline and follow-up to segment,
Mask1:capturing tumor+edema on T2W image;
Mask2:capturing tumor+necrosis on DWI and
Mask3:capturing necrosis on ADC map.
e) Finally, Mask (Edema) = Mask1–Mask2.
Mask (Active-Tumour) = Mask2–Mask3. Mask (Necrosis) = Mask3.

Figure 1: SLICs+MTh based segmentation. i) T2W image; ii) Supervoxels generation; iii) Otsu-Multi-thresholding for segmentation mask generation.



Statistical analysis:

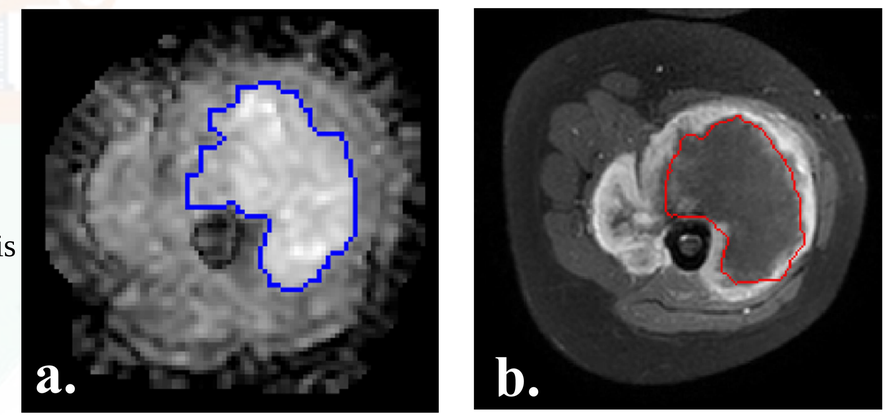
i) Segmentation accuracy metrics: Jacquard-index (JI), Dice-coefficient (DC), Precision (P) and Recall (R) evaluated between manually drawn Ground-truth region-of-interest (ROI) and SLICs+MTh based segmentation results.
ii) Post-contrast T1W images were used to validate the SLICs+MTh based necrosis.
iii) SLICs+MTh based necrosis volume were compared with HPE-necrosis using paired t-test ($p \leq 0.05$).

Result:

i) Segmentation accuracy at baseline and follow-up,
Mask1: JI:76-78%; DC:86-87%; PR=82-87%; RC=85-88%.
Mask2: JI=71-64%; DC=78-85%; PR=76-81%; RC=79-87%.
Mask3 : JI=64-68%; DC=72-78%; PR=67-75%; RC=70-76%.

ii) SLICs+MTh based necrosis area qualitatively and quantitatively (DC=74%) correlated well with the hypo-intense necrosis areas in post-contrast T1W images.

Figure 2: a) SLICs+MTh based necrosis area on ADC map; b) hypo-intense necrosis areas in post-contrast T1W image



iii) No significant difference(p>0.26) among SLICs+MTh based necrosis at follow-up and HPE-necrosis was observed.

Figure 3: Box and whisker plot showing tumor necrosis by SLICs+MTh method at baseline and follow-up and actual HPE necrosis.

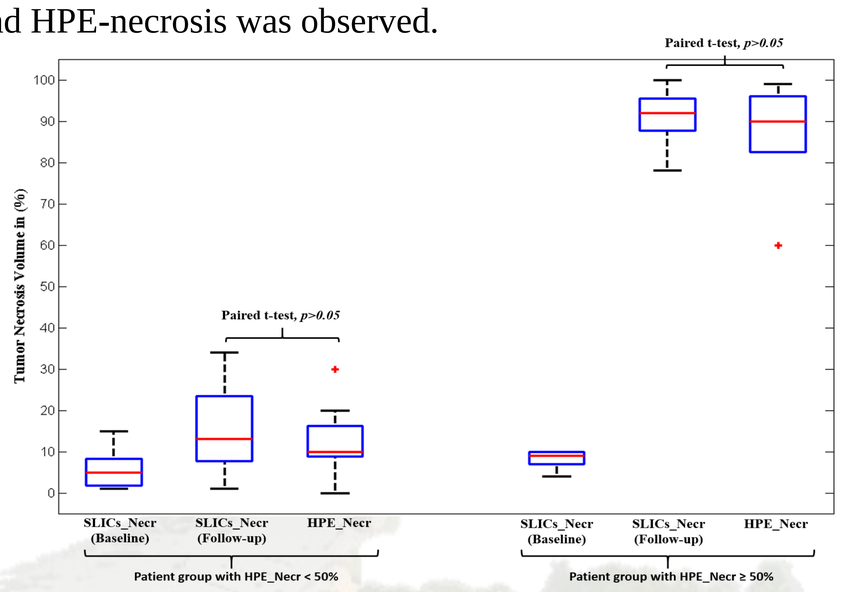
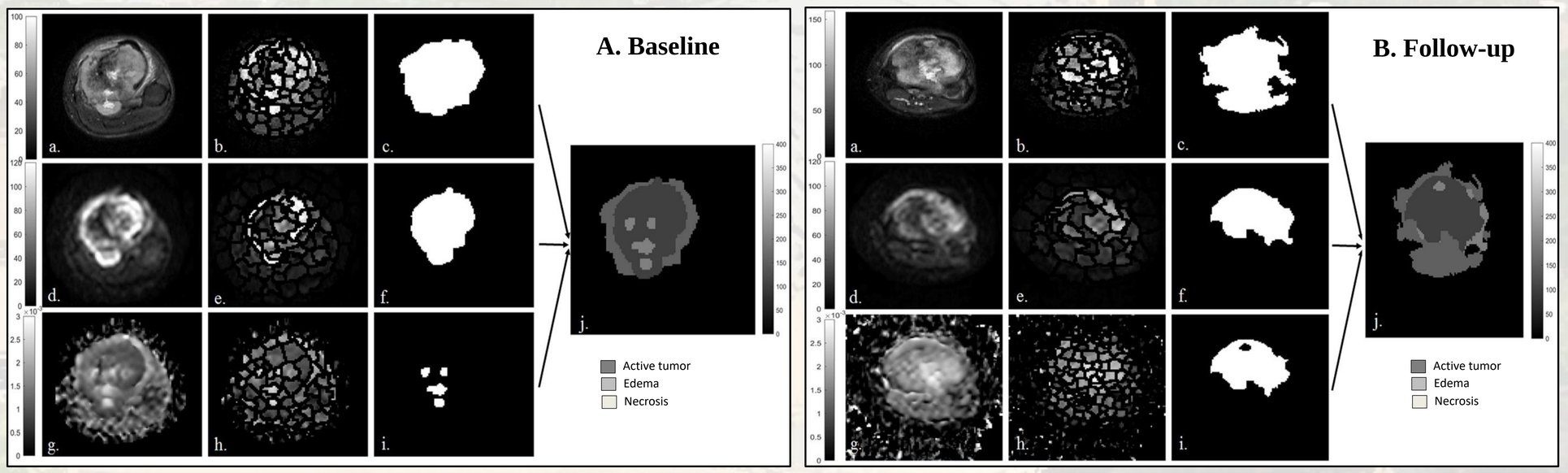


Figure 4: SLICs+MTh based segmentation of tumor, necrosis & edema at A. Baseline and B. Follow-up for a patient (M, 16yrs) with HPE necrosis of ~90% of tumor volume after surgery.



Conclusions:

Proposed technique is non-invasive, uses multi-parametric MRI to measure proportion of necrosis with respect to viable tumor as an indication of anti-cancer treatment response in bone tumor. This may be used as a clinical decision support for assessing treatment response in other types of tumor also .

Industrial Significance

A multi-parametric MRI analysis based methodology has been developed and clinically evaluated for non-invasive assessment of chemotherapeutic treatment response (necrosis) in Osteosarcoma in the course of treatment that may be used as clinical decision support system for treatment monitoring, personalized treatment planning improving overall prognosis.

Technology Readiness Level: TRL is 5-6 for this presentation.

References

[1] Murphey MD et al. RadioGraphics 1997;17(5): 1205–1231. [2] Achanta et al. IEEE Transactions on analysis and machine intelligence, vol. 34, NO. 11, Nov, 2012. [3] Irving et al. Med Image Comput Comput Assist Interv. 2014;17(Pt 1):609-16. [4] Mehndiratta et al. Proc. 26th ISMRM, 2018. https://www.ismrm.org/18/program_files/TP05.htm [5] Mehndiratta et al Proc. 27th ISMRM, 2019. https://www.ismrm.org/19/program_files/DP07.htm#002

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