Research paper

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Photopic (tint) ultrasound in musculoskeletal radiology – a pilot visual-grading/acceptability study

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ultrasonography; musculoskeletal system; color; image interpretation; radiology

Abstract

Background: While grayscale ultrasound is the standard in musculoskeletal imaging, photopic imaging, where the entire image is colorized, may enhance visual perception by leveraging human color discrimination. Despite its theoretical benefits, its clinical value remains underexplored. **Objective:** To assess the perceived interpretability/helpfulness, image quality, and visual appeal of photopic (tint) ultrasound imaging compared to conventional grayscale (B-mode) imaging in musculoskeletal radiology. **Methods:** A retrospective analysis reviewed 20 musculoskeletal cases sequentially collected from two centers. B-mode images were recolored using various tints on Siemens Acuson S2000 and GE Logiq Fortis equipment. Two final-year residents specializing in musculoskeletal radiology independently rated image quality, visual appeal, and diagnostic value on a 5-point Likert scale. Inter-rater agreement was assessed using Cohen's Kappa. **Results:** Tint images received consistently high scores, with a minimum rating of 4 across all categories. The images were rated a mean score of 4 for quality, visual appeal, and diagnostic value by both readers. Median and mode scores were 4 or 5 in all subcategories. High inter-rater reliability (Cohen's Kappa: 0.8) indicated strong agreement between reviewers. **Conclusion:** Photopic ultrasound imaging demonstrates high image quality, visual appeal, and perceived interpretability/helpfulness in musculoskeletal applications. The technique shows promise as a complementary tool to grayscale imaging, with potential benefits in teaching as well as clinical interpretation, particularly for trainees. Further research with larger cohorts and experienced radiologists is warranted.

Introduction and literature review

Ultrasound is routinely used in musculoskeletal radiology, where conventional grayscale 'B-mode' images are used to identify anatomical characteristics for diagnostic and interventional purposes. A lesser-used and lesser-known function is that of photopic, also termed 'tint', imaging. This refers to a feature on ultrasound imaging units to change the color map i.e., the entire image takes on a different hue (Fig. 1, Fig. 2, Fig. 3, Fig. 4), made possible by software converting B-mode grayscale display to photopic range via a single colorization. The hues are varied, including color schemes such as yellow-brown and blue-white. The aim of this study is to evaluate the utility of tint imaging compared to conventional grayscale ultrasound in musculoskeletal applications.

The purpose of tint is to optimize image contrast by taking advantage of the intrinsic human visual perception which distinguishes colors better than grayscale. The photoreceptors of the retina comprise rods and cones – the rods are specialized for scotopic vision, allowing for monochromatic vision of approximately 64 shades of gray at lower acuity and resolution[(1)]. The cones are specialized for photopic vision allowing for color, saturation, intensity, and luminance to facilitate the perception of millions of chromatic nuances[(1)].

The concept of color preference has been investigated across various healthcare disciplines. In one prospective observational case series in ophthalmology, subjects with normal vision and those with age-related macular degeneration were recruited to identify their chromatic (color) preference[(2)]. The majority of both groups pre-

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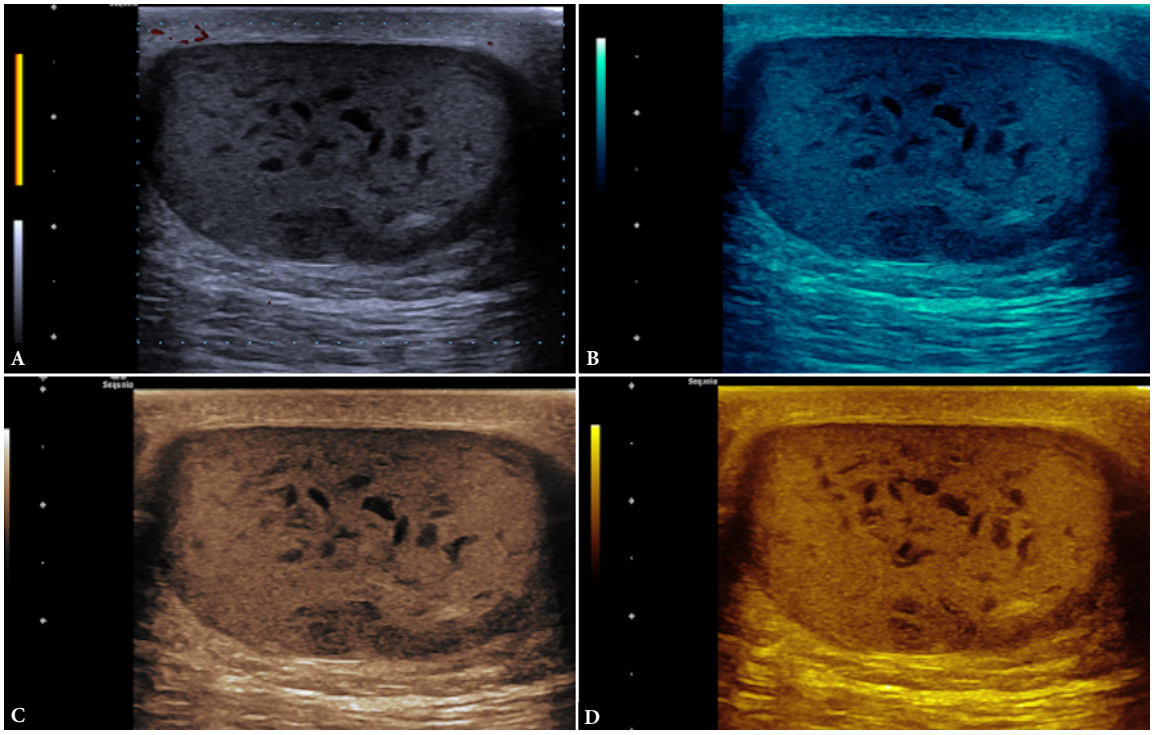

Fig. 1. *Grayscale (***A***) and various tints (***B–D***) of an epidermal inclusion cyst*

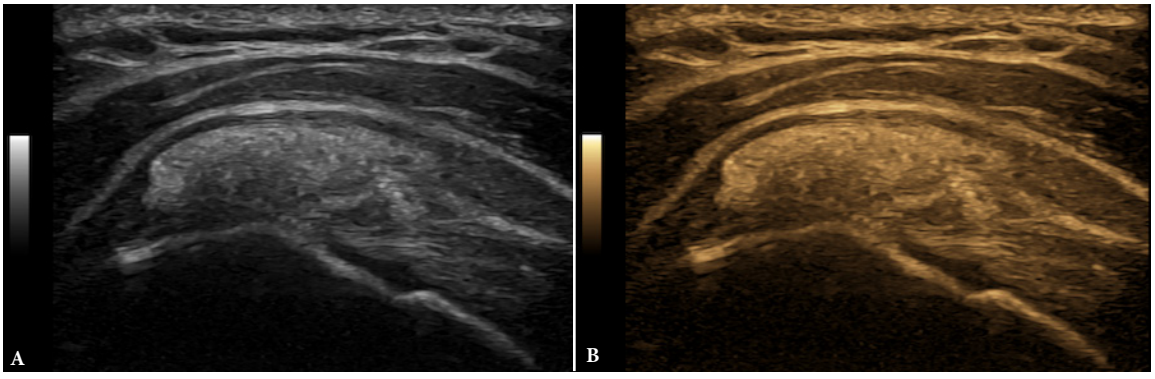

Fig. 2. *Grayscale (***A***) and tint (***B***) of supraspinatus calcific tendinopathy*

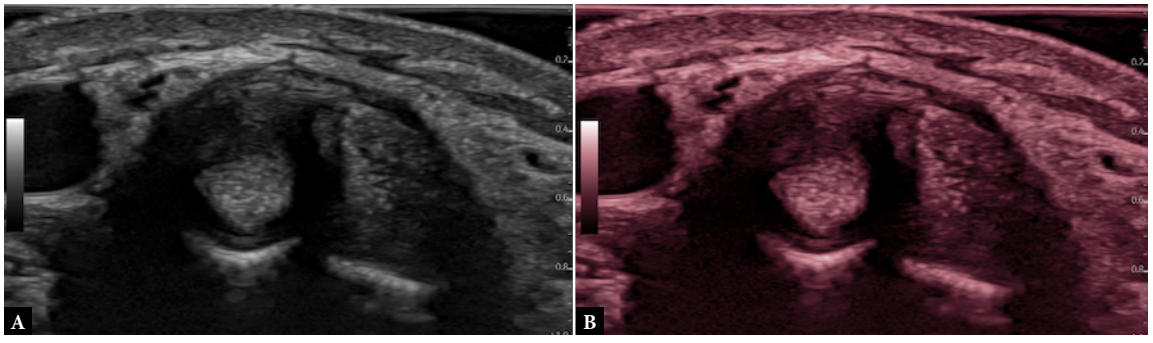

Fig. 3. *Grayscale (***A***) and tint (***B***) of de Quervain tenosynovitis*

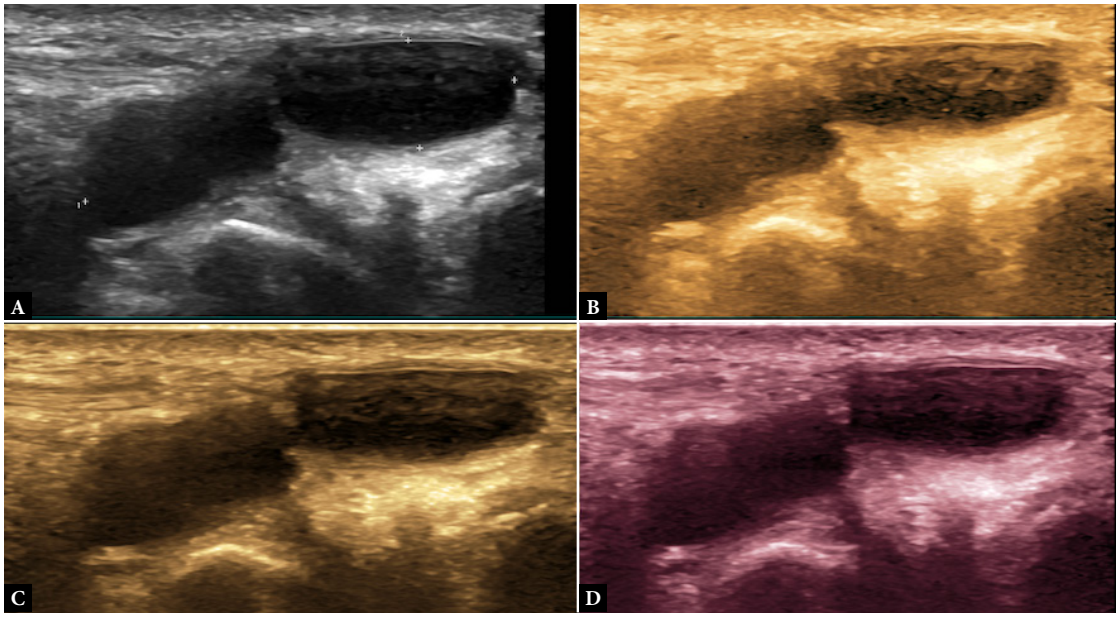

Fig. 4. *Grayscale (***A***) and various tints (***B–D***) of a ganglion*

ferred a yellow-hued background, raising the suggestion that yellow hues can be incorporated into various tasks. Chromatic information was especially helpful at lower spatial frequencies[2].

There are few contemporary published works examining the use of photopic ultrasound specific to musculoskeletal imaging. A study by Lin et al. evaluating photopic versus conventional grayscale sonography of plantar nerve neuromas concluded that photopic imaging significantly improved image contrast, especially regarding low lesion echogenicity[3]. Its application has also shown improvements in the evaluation of head and neck masses, as described by Kothe et al.[4]. In that study, photopic and conventional images were assessed based on overall visual impression, demarcation from adjacent tissues, overall echogenicity, and internal content echogenicity; the results suggest that photopic imaging was a useful complement in imaging practice[4]. The utility of photopic ultrasound imaging was further demonstrated by Fischer et al. in the field of abdominal and otolaryngological assessment[5]. Separately, a type of tint imaging (color mapping) is also one of the many techniques adopted in fetal cardiac imaging to optimize image quality[6].

While there are several terms used to describe photopic imaging, such as tint, it needs to be distinguished from other terms such as 'color-coded'. 'Color-coded' is a misnomer as it implies that a color is matched to a specific tissue property. This is not the case in tint/photopic imaging. Examples of color-coding include developments in brain MRI imaging, whereby automated tools quantify various features of the brain, such as volume for neurodegenerative disease assessment or disease progression in multiple sclerosis[7,8]. In these instances, different colors are assigned to parts of the same image based on intrinsic tissue characteristics. Another similar but different concept is that of elastography in musculoskeletal imaging, whereby the biomechanical properties of the tissues are assessed and displayed with color mapping[9].

Material and methods

A retrospective analysis was performed using data collected from two centers. Local ethical committee approval was obtained: ECLAT/27J/2025 and Imaging/SE/2025-26/25. As this is a small pilot study, cases were selected within a timeframe rather than based on specific pathology. A series of 20 sequential cases were collected by a senior musculoskeletal radiologist. Initial ultrasound images were obtained in B-mode and subsequently a tint was applied to produce a photopic image, with all other device settings unchanged. Various color tints using inbuilt factory settings or defaults were used. Images were acquired on Siemens Acuson S2000 or GE Logiq Fortis ultrasound equipment using the inbuilt tint software (Fig. 1, Fig. 2, Fig. 3, Fig. 4).

The images were extracted, collated, and reviewed independently. A mixture of various tints with grayscale was considered the gold standard for this study. Independent reviews were carried out by two final-year radiology residents with subspecialty interests in musculoskeletal radiology. The criteria used to evaluate the tint images included quality of images, visual appeal, and diagnostic value scored using a Likert scale of (1) poor, (2) fair, (3) good, (4) very good, and (5) excellent.

Statistical analysis

The Likert scores from both readers were analyzed. SPSS was used to calculate Cohen's Kappa inter-rater reliability (i.e., the level of agreement between the two raters beyond what is expected by chance). Further computation included that of the mean, median, and mode to assess the overall distribution in each category.

Results

The Cohen's Kappa inter-rater reliability was 0.8, indicating a high level of agreement between the two radiology residents.

The overall mean scores for the tint images, taking into account quality, visual appeal, and diagnostic value, were 4 points for both raters. Regarding solely the diagnostic value, the median and mode scores were 5 for one rater and 4 for the other rater. Visual appeal was ranked the same (mean, median, and mode) for both raters. For quality of images, the median and mode value were 5 points for one rater and 4 for the second rater. The IQR (interquartile range) for quality of images was 4–5, visual appeal 3–4, diagnostic value 3–4, and overall was 3.75–4.25. The overall median was 4 for all four parameters.

Of note, the minimum score given was 4, suggesting that the diagnostic images demonstrated overall good quality and were visually appealing across the multiple pathologies scanned.

Discussion

Ultrasound is an invaluable tool in musculoskeletal radiology, both in standalone use as well as in complementing other modalities. It allows for real-time dynamic assessment, gives physiological information, is compatible with prostheses, is widely available, guides therapeutic intervention, and has good resolution[10]. These benefits can be further enhanced with the tint function. This is because color helps in spatial vision by segregating the visual scene into discrete objects[11]. Color can also aid in data categorization coding into memory[11]. As indicated by the results, the overall assessment of the tint images scored at least 'very good' for all 20 different musculoskeletal cases. This indicates that in a variety of pathologies, it is perceived as useful and effective by residents specializing in musculoskeletal radiology.

If both tint and grayscale images are reviewed, a possible pedagogical benefit is that of scaffolding knowledge by presenting the same pathology slightly differently to serve as a reiteration of knowledge, which is a useful pedagogical technique[12]. Generating and reviewing tint images in addition to grayscale images allows learners to actively select pieces of information and make connections between them. This, in turn, reinforces understanding[12] and would be useful in teaching musculoskeletal radiology.

Furthermore, its utility also derives from the intrinsic requirement of color vision to operate at relatively high light level[11], as opposed to grayscale vision, which operates a lower light level. This is convenient in a conventional outpatient or intensive care setting, where ambient light may not be easily controlled. It is also a useful adjunct when the intrinsic contrast of the tissues may be low, as previously elaborated by Lin et al.[3].

As with any function, it can take time for operators to become accustomed to the tint images. Despite the benefits as described, the end-user experience may vary and may ultimately be preference-dependent. A limitation of our study would be the consideration that the assessors were residents (albeit in their final year of training) rather than experienced consultants. However, the use of tint is arguably more useful in this cohort of radiologists; this group is still gaining experience and can benefit from the augmentation provided by tint to pick up subtle ultrasound findings. In contrast, experienced radiologists would better compensate for the shortcomings of solely using conventional grayscale imaging.

This pilot study demonstrates that tint images offer promise for daily use, as observed in real-life application by a musculoskeletal radiologist and assessed by subspecialty radiology residents. Future direction would entail subgroup analyses with categories of pathologies, larger sample sizes, and consideration for blinding between tint and grayscale images.

Conclusion

This pilot study demonstrates that photopic (tint) ultrasound has use in the realm of musculoskeletal sonography. While there is a dearth of existing contemporary literature, this study illustrates the overall good performance of tint images from the perspective of musculoskeletal radiology. Furthermore, the rater evaluation was consistent, as indicated by high inter-rater agreement. We conclude that the visual cues provided by tint images may aid in demonstrating pathologies in a visually appealing fashion.

Declaration

Local ethical committee approval was obtained (ECLAT/27J/2025 and Imaging/SE/2025-26/25).

The authors declare that they have no conflicts of interest.

Conflict of interest

The authors do not report any financial or personal connections with other persons or organizations which might negatively affect the contents of this publication and/or claim authorship rights to this publication.

Author contributions

Original concept of study: SL, HU, NR, AS, RB. Writing of manuscript: SL. Analysis and interpretation of data: SL, RB. Final acceptance of manuscript: RB. Collection, recording and/or compilation of data: SL, AS. Critical review of manuscript: SL, HU, NR, AS, CS, RB.

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