

## Evaluation of histological characteristics of meniscus using spectral colorimeter

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**INTRODUCTION:** Meniscal repair has been increasing year by year, as preservation of the meniscus is emphasized from the viewpoint of knee osteoarthritis [1]. In addition, treatment methods that aim to promote repair and regeneration using bioactive substances, cells, and absorbable materials have been developed and are attracting attention. When performing arthroscopic treatment in the clinical setting, surgeons have empirically noticed that the tissues become brownish in color with age (Figure 1A). Accumulation of advanced glycation end-products contributes to yellowing of the tissue and to organizational vulnerability [2]. And the tissue characteristics of the meniscus of each individual patient are one of the factors that influence the outcome of treatment. We hypothesize that tissue browning reflects tissue degeneration. The purpose of this study was to clarify the relationship between color information and tissue characteristics of the meniscus.

**METHODS:** In this study human meniscus tissues were obtained by arthroscopic partial meniscectomy due to clinically symptomatic meniscus injury (16 males and 12 females, mean age 37.3 years, 7-75 years). The collected pieces of medial menisci from 8 patients and the lateral menisci from 20 patients were evaluated. For color information, L\*a\*b\* values defined by the International Commission on Illumination were measured from the surface of tissues by using a spectral photometer (Nippon Denshoku Kogyo, SE7700) (Figure 1B). L\*, a\*, and b\* values represent tissue brightness, green to red, and blue to yellow, respectively. Measurements were performed at three points of tissue surface and the average values were used. The tissue were fixed with 4% paraformaldehyde. Safranin-O/fast green and hematoxylin-eosin staining were performed with paraffin sections, and histologically evaluated using the Pauli's score to investigate their relevance. Due to the sample from partially meniscectomy, the surface was evaluated with a score of 9 to 3, for a total of 12 points as modified Pauli's score. We defined 0-2 (grade1) as normal tissue, 3-5 (grade2) as mildly degenerated, 6-8 (grade3) as moderately degenerated, and 9-12 (grade4) as severely degenerated. In addition, immunohistological staining for type I collagen was performed and then, positive cells were counted. The data were analyzed with Spearman's rank correlation coefficient. P values <0.05 were considered to be statistically significant.

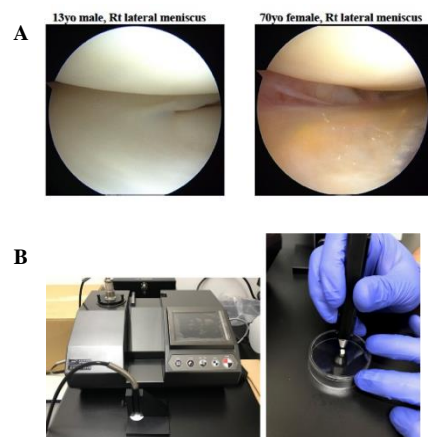
**RESULTS:** The modified Pauli's grade demonstrated 6 cases of grade1, 11 cases of grade2, 10 cases of grade3, and 1 case of grade4 (Figure 2). There was no correlation between age and grade. The relationship between the color information and age, there was significant correlation between b\*, i.e. yellowish in color, and age ( $r = 0.794$ ,  $P < 0.001$ ), however, there was no correlation with L\* and a\* (Figure 3A). Comparing histological score with color information, total score demonstrated significant positive correlation only with b\* ( $r = 0.541$ ,  $P = 0.003$ ) (Figure 3B). In each parameter of Pauli's scoring system, surface and cellularity demonstrated positive correlation with b\* ( $r = 0.444$ ,  $P = 0.018$  and  $r = 0.449$ ,  $P = 0.017$ , respectively). On the other hand, neither age nor modified Pauli's score correlated with the number of type I collagen-positive cells.

**DISCUSSION:** We revealed an association between color information and age and histological degeneration. In particular, age and modified Pauli's score was positively correlated with the degree of browning. Previous reports have focused on brown degeneration and its relationship to pentosidine, advanced glycation end-products (AGEs), and have shown that pentosidine increases with age and in degenerated menisci, similar to the results of this study [3]. However, research has not progressed on its subsequent clinical application. Otani et al. reported that there is a strong correlation between the surface appearance of the Pauli's score and tissue degeneration, with surface appearance reflecting the secretion of inflammatory cytokines from histological analysis [4]. Our approach using spectral colorimeter enable us no invasive and objective evaluation and has a potential to obtain histological information of meniscus.

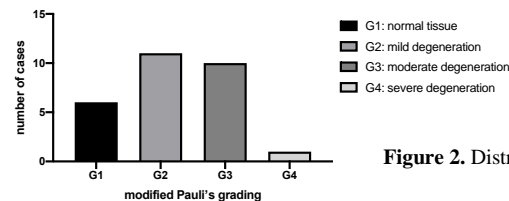
**SIGNIFICANCE/CLINICAL RELEVANCE:** As far as we know, this is the first study to investigate meniscus color information comparing with histological grading using the spectral colorimeter. Color information has a potential to know tissue property, to predict clinical outcome, and to decide whether perform meniscal repair or meniscectomy during surgery.

### REFERENCES:

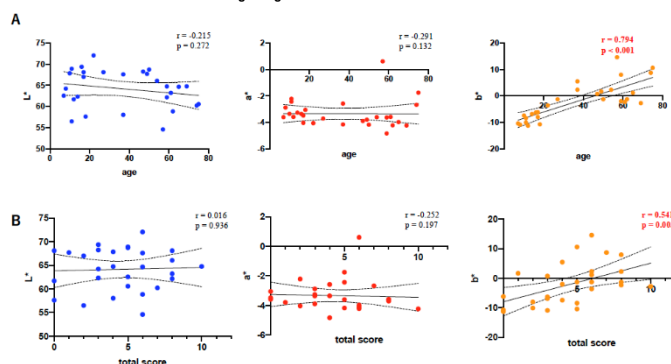
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**Figure 1.** Arthroscopic images of meniscus (A) and a spectral photometer (left) and pen type optical fiber (B).



**Figure 2.** Distribution of modified Pauli's grade



**Figure 3.** Correlation with color information with age (A) and histological score (B)