

## Observational Study

## “Meniscal” scar as a landmark for the joint line in revision total knee replacement

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### Abstract

#### AIM

To determine whether tissue identified at the joint line was actually remnant “meniscal” scar tissue or not.

#### METHODS

Nine patients undergoing revision knee surgery following informed consent had meniscal scar tissue sent to the histology department for analyses. All revisions were performed where joint line had been raised or lowered at earlier surgery. Although preoperative radiographic evaluations suggested that the joint line had been altered, intraoperatively there was scar tissue at the level of the recreated joint line. This scar tissue has traditionally been described as meniscal scar, and to identify the origins of this tissue, samples were sent for histological analyses. The tissue samples were stored in formalin, and embedded and sectioned before undergoing histochemical staining. All samples underwent macroscopic and microscopic examination by a histopathologist who was blind to the study aims. The specific features that were examined included tissue organisation, surface and central composition, cellular distribution including histiocytes, nuclear ratio and vasculature. Atypical and malignant features, inflammation and degeneration were specifically looked for. A statistical review of the study was performed by a biomedical statistician.

#### RESULTS

The histological findings for the nine patients showing

the macroscopic and microscopic findings, and the conclusion are outlined in a Table. The histological analyses were reviewed to determine whether the tissue samples were likely to be meniscal scar tissue. The response was yes (2, 22%), no (6, 67%) and maybe (1, 11%) based on the conclusions. The results were "yes" when on macroscopy, firm cream tissue was identified. In these two "yes" samples, microscopic analyses showed organised fibrous tissue with focal degenerative areas with laminated pattern associated with histiocytes peripherally but no inflammation. The "no" samples were assessed macroscopically and microscopically and were deemed to have appearances representing fibrous synovial tissue and features in keeping with degenerate scar tissue or connective tissue. One sample was indeterminate and microscopically contained fibro-collagenous tissue with synovial hyperplasia. It also contained some degenerate hyalinised tissue that may represent cartilage, but the appearances were not specific.

### CONCLUSION

Based on our pilot study, we recommend reliance on a number of markers to identify the joint line as outlined above, and to exercise caution in using the "meniscal" scar.

**Key words:** Meniscal scar; Joint line; Revision surgery; Knee; Histology

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**Core tip:** Our findings suggests that the structure identified as the "meniscal" scar may actually represent scar tissue that forms in the available space of the recreated joint line rather than actually represent the level of the native joint line where the meniscus once attached.

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### INTRODUCTION

Revision total knee arthroplasty (TKA) is a complex procedure that generally does not achieve the same good results as primary knee replacement. There are a number of reasons for this and include the complexity of the revision procedure making it difficult to restore the joint line<sup>[1-3]</sup>. Restoring the joint line is associated with improved clinical outcomes, functional knee scores and range of motion as well as decreased anterior knee pain<sup>[4]</sup>. In revision surgery the joint line can more commonly become elevated due to distorted anatomical

landmarks, excessive distal femoral bone resection and using an excessively thicker a tibial insert. Excessive distal femoral bone loss may be due to excessive bone resection at the primary joint replacement or as a result of deficient bone stock from infection, osteolysis, peri-prosthetic fracture, component migration or iatrogenic damage when attempting to remove implants and cement in revision surgery<sup>[1,3]</sup>. It is therefore proposed that distal femoral augments should be used rather than thicker polyethylene to avoid elevation of the joint line.

A number of landmarks have been described in the literature to facilitate the accurate reproduction of the joint line in revision TKA and include the (1) the "meniscal" scar; (2) 1.5-2 cm proximal to the fibular head; (3) 2 cm proximal to the tibial tubercle; (4) 2-2.5 cm distal to the lateral femoral epicondyle; and (5) 2.5-3 cm distal to the medial femoral epicondyle<sup>[5,6]</sup>. Other measurements used include two finger breadths above the tibial tubercle or 2 cm below the inferior patella pole in extension<sup>[7]</sup>. Less commonly used reference points include the adductor tubercle<sup>[7,8]</sup>. Some surgeons obtain historical radiographs of the ipsilateral, or up-to-date radiographs of the contralateral knee to help identify the location of the joint line relative to fixed bony landmarks<sup>[4,7]</sup>. Variations in technique exist when measuring from radiographs and other potential drawbacks include malrotation and magnification that can cause inaccurate measurements<sup>[5]</sup>.

The bony and radiological methods described to identify the joint line can be unreliable and are not standardised or reproducible. The bony landmarks may not be easily accessible or identifiable intraoperatively and hence the greater reliance on the "meniscal" scar. We performed a histological study to determine whether tissue identified at the joint line was actually remnant "meniscal" scar tissue or fibrous tissue formed at the level of the recreated joint line from the previous surgery.

### MATERIALS AND METHODS

Nine patients undergoing revision knee surgery following informed consent had "meniscal" scar tissue sent to the histology department for analyses. All revisions were performed where joint line had been raised or lowered at earlier surgery. Although preoperative radiographic evaluations suggested that the joint line had been altered, intraoperatively there was scar tissue at the level of the recreated joint line. This scar tissue has traditionally been described as meniscal scar but to identify the origins of this tissue, samples were sent for histological analyses.

The tissue samples were stored in formalin, embedded and sectioned before undergoing histochemical staining. All samples underwent macroscopic and microscopic examination by a histopathologist who was blind to the study aims. The specific features that were examined included tissue organisation, surface

**Table 1** Histological reports for nine patients showing the macroscopic and microscopic findings, and the conclusion

| Patient | Macroscopy              | Microscopy  | Conclusion  | Is the tissue likely to be meniscal scar tissue? |
|---------|-------------------------|---|---|--|
| 1       | Cream tissue            | Organised fibrous tissue and synovial surface. No atypical features   | Appearances likely represent fibrous synovial tissue                    | No   |
| 2       | Yellow and white tissue | Fragments of fibrous tissue partly lined by synovium show focal areas of denuded surface with acellular fibrinoid exudate. No significant inflammation                                      | Features in keeping with degenerate scar tissue                         | No   |
| 3       | Firm cream tissue       | Fibrous tissue with focal degenerate area. No inflammation seen   | Meniscal tissue   | Yes  |
| 4       | Firm cream tissue       | Sections showing organised fibrous tissue and laminated pattern associated with foamy histiocytes at the periphery under the synovial surface. In areas the fibrous tissue lack nuclei      | Appearances likely represent meniscal remnants with degenerate features | Yes  |
| 5       | Firm cream tissue       | Fragments of connective tissue. No features of atypia, malignancy, or significant inflammation  | Connective tissue   | No   |
| 6       | Cream tissue            | Fragments of fibrous tissue with overlying synovium. There is a mild inflammatory infiltrate  | Features in keeping with fibrous scar tissue                            | No   |
| 7       | Firm cream tissue       | Sections show fragments of connective tissue. No evidence of atypia or malignancy. No significant inflammation is identified. There is a small collection of blood vessels seen in one edge | Connective/scar tissue  | No   |
| 8       | Cream tissue            | Fibro-collagenous tissue with synovial hyperplasia. Some degenerate hyalinised tissue that may represent cartilage, but the appearances are not specific                                    | Features in keeping with non-specific articular tissue                  | Maybe  |
| 9       | Yellow and white tissue | Fibrous tissue with no significant inflammation   | Degenerate scar tissue  | No   |

The histological analyses were reviewed to determine whether the tissue reported was likely to be meniscal scar tissue.

and central composition, cellular distribution including histiocytes, nuclear ratio and vasculature. Atypical and malignant features, inflammation and degeneration was specifically looked for. A statistical review of the study was performed by a biomedical statistician.

## RESULTS

The histological findings for nine patients showing the macroscopic and microscopic findings as well as the conclusion are outlined in Table 1. The histological analyses were reviewed to determine whether the tissue samples were likely to be meniscal scar tissue. The response was yes (2, 22%), no (6, 67%) and maybe (1, 11%).

## DISCUSSION

Restoring the joint line is important in knee surgery. Joint line elevation can cause patella baja, patella button impingement, accelerated wear and loosening, quadriceps weakness, anterior knee pain, laxity in knee mid-flexion, varus-valgus instability and hyperextension instability<sup>[1]</sup>. It also results in decreased knee range of motion caused by impingement of the patellar implant on the tibial component<sup>[9,10]</sup>. Mid-flexion instability is caused by tight posterior structures that provide stability in extension and at 90 degrees of flexion<sup>[6]</sup>. A recent review of studies demonstrated elevation of the joint line in 79% of revision TKAs by 3-13 mm<sup>[2,5,7]</sup>. Singerman *et al*<sup>[11]</sup> demonstrated that raising or lowering the joint line in revision TKA by more than

8 mm resulted in a decreased range of motion and lower modified Mayo Clinic knee scores. In another study, elevation greater than 8 mm was associated with reduced mean Knee Society scores of 141 vs 125<sup>[3]</sup>. Several studies have shown that elevation more than 5 mm significantly affects the functional outcome in revision TKA<sup>[1]</sup>. Mason *et al*<sup>[5]</sup> showed a significant difference in total Bristol knee scores and the functional component of the score when there was more than 5 mm elevation of the joint line. Proximal joint line displacement of more than 5 mm caused decreased knee flexion, increased patellofemoral forces that can cause pain, subluxation, dislocation, fracture and increased varus-valgus instability particularly in mid-flexion in cadaveric knees<sup>[12]</sup>. A less common occurrence of distal placement of the joint line, patella alta, can alter tracking of the extensor mechanism that can cause increased patellar strain<sup>[11]</sup>. Although Scuderi and Insall suggest that elevation of the joint line by 10 mm has no significant clinical effect<sup>[13]</sup>, and Partington *et al*<sup>[3]</sup> demonstrated only a marginal statistical significance in clinical scores in a series of 99 revision TKA cases with more than 8 mm elevation of the joint line the overwhelming evidence points to the restoration of the joint line being important for a good clinical result.

The "meniscal" scar is increasingly being used to identify the level of the native joint line in revision knee surgery. The menisci are two fibrocartilagenous, semilunar concave shaped tissues that rest on the medial and lateral tibial plateau. Functions of the menisci include assistance in joint stability, to bear and transmit loads within the knee and to act as "shock

absorbers"<sup>[14]</sup>. The normal meniscus contains two cell populations, fibroblasts on the meniscal surface and fibrochondrocytes in the inner surface. Meniscus tissue has a complicated shape and anchoring network, but displays great regional variation in its extracellular matrix components. The menisci consist of water (75%), water (20%), type I collagen and other substances (5%); including proteoglycans, elastin and type II collagen. The majority of collagen fibres are arranged circumferentially with some running radially. The meniscal periphery is highly fibrous and abundant in cells and collagen type I, with the inner portion of the tissue resembles hyaline cartilage with fewer cells, type II collagen and higher proteoglycan content. The outer portion of the meniscal tissue is highly vascularized, in comparison to the inner menisci that is devoid of blood vessels<sup>[14]</sup>. There are several morphological variations in meniscal tissue with cells being classified as fibroblasts, fibrocytes, chondrocytes, fibro-chondrocytes and meniscus cells by researchers. However these morphologies have various cell profiles. Cells in the superficial meniscal layer are oval or fusiform in shape and represent fibroblast morphology. Cells in the deeper meniscal layer have a more spherical appearance similar to chondrocytes. The outer proportion of meniscus contains type I collagen predominantly with fibrocartilaginous matrix. The inner meniscus is more hyaline-like consisting of predominantly type II collagen and contains chondrocyte-like cells<sup>[14]</sup>. Meniscal tissue may contain few or no intrinsic viable cells<sup>[15]</sup>.

These features suggest that it is reliable histologically to identify meniscal tissue. Our pilot study only identified 33% of samples as potentially being of meniscal origin. The remaining 67% were not likely to be of meniscal origin. This suggests that the structure identified as the "meniscal" scar may actually represent scar tissue that forms in the available space of the joint line rather than actually represent the level of the native joint line where the meniscus once attached. This has significant implications on restoring the joint line. We recommend reliance on a number of markers to identify the joint line as outlined above and to exercise caution in using the "meniscal" scar.

## COMMENTS

### Background

During primary and revision knee surgery, it is important to restore the joint line but this can be difficult especially where there has been previous trauma, surgery or infection. A number of landmarks have been described in the literature to facilitate the accurate reproduction of the joint line in revision total knee arthroplasty (TKA) and include the "meniscal" scar amongst others.

### Research frontiers

A number of landmarks have been described in the literature to facilitate the accurate reproduction of the joint line in revision TKA but none of them are absolutely accurate. The bony and radiological methods to identify the joint line can be unreliable, and are not standardised or reproducible. The bony landmarks may not be easily accessible or identifiable intraoperatively and hence the greater reliance on the "meniscal" scar.

## Innovations and breakthroughs

The authors' findings suggest that the structure identified as the "meniscal" scar may actually represent scar tissue that forms in the available space of the recreated joint line rather than actually represent the level of the native joint line where the meniscus once attached.

## Applications

The research has significant implications on restoring the joint line. The authors recommend reliance on a number of markers to identify the joint line as outlined in this paper, and to exercise caution in using the "meniscal" scar.

## Terminology

The "meniscal" scar is the remnant soft tissue on the peripheries of the knee joint after excision of the menisci during earlier knee arthroplasty surgery.

## Peer-review

The present study described the "meniscal" scar as one of many landmarks used to identify the native joint line. It's a very well written paper.

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