Association between power Doppler ultrasonography signals and chronic pain after total knee arthroplasty – a longitudinal study

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INTRODUCTION:
Total knee arthroplasty (TKA) is an established intervention for knee osteoarthritis (OA) pain. However, a significant subset of patients experience chronic post-surgical pain (CPSP) post-TKA, highlighting the need for further research into its underlying causes. Current understanding points to several factors including preoperative pain, gender, and postoperative alignment. Synovitis, a notable pain contributor in osteoarthritis, has also been identified post-TKA. Kurien's findings on postoperative synovitis on MRI, and our previous study, using ultrasound power Doppler, linked pain with this condition. Yet, the relationship's trajectory and its predisposing factors remain less clear. Our previous cross-sectional design limited the examination of potential preoperative influencers on post-TKA synovitis. In this study, we aim to longitudinally assess the relationship between post-TKA CPSP and synovitis, while also evaluating potential preoperative factors contributing to post-TKA synovitis.

METHODS:
This prospective longitudinal study examined the relationship between post-TKA pain and its determinants, with an emphasis on synovitis, over a one- or two-year postoperative period. Patients from Kochi University Hospital who underwent TKA between September 2020 and October 2021 were recruited. Inclusion criteria encompassed TKA patients with osteoarthritis diagnosis, while exclusions pertained to infections, malalignment, and other causes of limb pain. Demographic data such as age, sex, BMI, diabetes history, and patient-reported outcomes (PROMs) like WOMAC and VAS for pain were gathered pre and post-surgery. Synovitis assessment utilized the total PD score, derived from the power Doppler ultrasonography grade (Fig.1) across 15 knee areas (Fig.2). MRI evaluations employed the MOAKS scoring system for synovitis, and radiographs pre- and post-surgery assessed alignment. All surgical procedures were standardized, performed by seasoned surgeons. The WOMAC pain subscale and total PD score at one and two years post-TKA were used as dependent factors to ascertain the causes of pain and synovitis at the respective time points. Initial associations were identified using univariate linear regression, followed by a stepwise multivariate linear regression analysis.

RESULTS:
We assessed 49 knees in 42 patients (Female/Male: 31/11) with an average age of 73.1 (SD 6.7). Preoperative, six-month, one-year, and two-year postoperative total PD scores were 4.1(2.9), 6.2(5.1), 4.5(4.3), and 3.2(3.1), respectively.
<Prognostic indicators for pain outcome>
Univariate linear regression showed significant associations of one-year WOMAC pain subscale with preoperative WOMAC pain subscale, CRP level three days post-surgery, postoperative patellar tilting angle, and one-year total PD score; and of two-year WOMAC pain subscale with BMI, postoperative lateral distal femoral angle, and two-year total PD score. In the multivariate model, only the preoperative WOMAC pain subscale (β: 0.189, SE: 0.09, p: 0.048) and one-year total PD score (0.202, 0.088, 0.029) remained significantly associated with one-year WOMAC pain subscale, with an adjusted R^2 of 0.167. The two-year total PD score (0.293, 0.120, 0.022) was associated with the two-year WOMAC pain subscale, with an adjusted R^2 of 0.398.
<Prognostic indicators for synovitis outcome>
Univariate regression identified age, BMI, Hoffa synovitis, and postoperative patellar tilting angle as significantly associated with the one-year total PD score, and BMI, preoperative medial proximal tibial angle, preoperative total PD score, and postoperative patellar tilting angle with the two-year total PD score. In the multivariate analysis, only BMI (-0.359, 0.118, 0.004) remained significantly related to the one-year total PD score, with an adjusted R^2 of 0.263. Both BMI (-0.222, 0.080, 0.009) and preoperative total PD score (0.312, 0.143, 0.004) correlated with the two-year total PD score, exhibiting an adjusted R^2 of 0.284.

DISCUSSION:
Pain experienced at one and two years post-TKA correlated with total PD scores during the corresponding periods in multivariate linear regression analysis. These findings corroborate prior studies positing a link between post-TKA synovitis and CPSP. While the total PD score increased post-TKA, it ameliorated by the second year, albeit residuals persisted. The two-year total PD score correlated with the preoperative score, but the one-year score did not. This suggests that TKA-induced synovitis resolves by the second year, but individual predispositions linger. Study limitations include a modest patient cohort, a brief follow-up duration, and the omission of confounding factors such as the central sensitization inventory or the catastrophizing scale, which influence CPSP.

SIGNIFICANCE/CLINICAL RELEVANCE:
This study elucidates the link between post-TKA synovitis and chronic pain, offering insights for enhanced patient care. By identifying preoperative predictors and post-TKA synovitis trends, clinicians can optimize interventions and improve postoperative outcomes.

<Fig.1>Representative images of power Doppler (PD) ultrasonography. The left and right images show PD grade 1 and grade 2 synovitis, respectively.
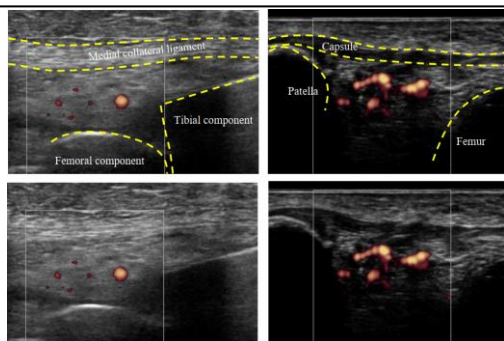
<Fig.2> The knee joint was divided into the 15 areas with grid lines for knee-synovitis mapping.