INTRODUCTION: Many trauma surgeries and reconstructive surgeries involve re-establishment of a bone-tendon (B-T) junction, such as repair of patella fractures. In case of comminuted patella fractures, partial patellectomy has become a option of surgical repair. But direct B-T junction repair is slow due to poor regenerative capability of its junctional fibrocartilage zone. Biophysical intervention using low intensity pulsed ultrasound stimulation (LIPUS) has been demonstrated to improve tissue repair for the regeneration of removed distal patella treated controls (Fig. 5). This was shown in evaluation in the regeneration of removed distal patella and the restoration of the junctional fibrocartilage zone. No difference in size of new bone formation between week 8 and week 16 after surgery suggested the treatment efficacy in LIPUS in early phase of healing. The better repair under LIPUS treatment might be explained by its promotion effects in vessel formation as revealed by higher VEGF expression and stimulation of bone formation. The extent of the outgrowth was observed to be generally associated with better restoration of the junctional fibrocartilage zone. However, substantiation on this observation is needed by the ongoing histomorphometrical analysis. The enlargement of the remaining patella after partial patellectomy might reduce the stress to the patellofemoral joint, potential stress-induced deterioration of its articular cartilage and improvement of knee joint function. As LIPUS is a non-invasive and non-destructive approach, it may have clinical potentials for earlier and active rehabilitation of injuries involving BT junction repair.

METHODS: Standard partial patellectomy was conducted in ninety-six 18 week-old rabbits and then divided them into LIPUS and control group for both/both groups. The rabbits were sacrificed at week 8 and 16 postoperatively, where the patella-patellar tendon (PPT) complex was obtained for mechanical tests, only for week 8 and 16. 1) Radiographic analysis: anterior-posterior x-ray film of PPT complex was taken to measure size of new bone formation at the B-T junction healing interface (Fig. 1). microCT was used to review the new bone formation at the B-T junction healing interface (Fig. 1). 2) Histology: paraffin sections of sagittal PPT complex were stained with H&E to evaluate general morphology of BT junction fibrocartilage zone (Fig. 2). VEGF and type III collagen were also evaluated at the junction zone immunohistologically. Rate of bone formation and remodeling at healing interface was also evaluated in undecalcified sagittal sections using sequential fluorescence labeling with calcine green and xylene orange by studying their labeled area. 3) Mechanical testing: PPT complex harvested at week 8 and 16 was used for tensile test at a speed of 2.0 mm/min using our established protocol. The maximum failure load was recorded. The tensile stress was calculated by normalizing the maximum load over the cross-sectional area of BT healing interface measured using a highly precise peripheral quantitative computed tomography (pQCT) ANOVA was used for statistical analysis.

RESULTS: 1) Radiographs measurements showed significantly more bone formation in terms of new bone outgrowth in LIPUS treated group as compared with the controls at both week 8 and 16 after partial patellectomy (P<0.01) (Fig. 3). However, no difference was detected as comparison was made between the two healing time points. 2) Histologically, no tissue integration was observed at BT junction in the week 2 samples in both groups. LIPUS treated samples harvested at week 4 revealed tissue integration at healing junction. Week 8 LIPUS treated samples showed improved tissue integration, characterized with outgrowth of trabecular bone from the remaining patella, formation of fibrocartilage layer at the healing junction. Safranin O staining showed earlier and richer proteoglycans distribution at healing junction and thicker restored fibrocartilage zone in LIPUS treated group as compared with that of controls. VEGF expression was stronger expressed at the BT healing interface in LIPUS treatment group than that in the control at week 2. Higher VEGF expression was then revealed in the control group at week 8. More collagen type III expression was found in LIPUS treated group in the week 4 and 8. Early bone formation and faster remodeling was shown in LIPUS treated groups as measured for the florescence labeled area at week 8 and 16 (Fig. 4). 3) Mechanical testing results showed significantly higher maximum tensile load and stress in LIPUS group at both 8 and 16 weeks as compared with that of the non-LIPUS treated controls (Fig. 5).

DISCUSSION: This was the first study to show that LIPUS was able to accelerate BT-junction repair in a partial patellectomy model in rabbits. This was shown in evaluation in the regeneration of removed distal patella for both new bone formation or ‘outgrowth’ of the new bone from the remaining proximal patella and the restoration of the junctional fibrocartilage zone. No difference in size of new bone formation between week 8 and week 16 after surgery suggested the treatment efficacy in LIPUS in early phase of healing. The better repair under LIPUS treatment might be explained by its promotion effects in vessel formation as revealed by higher VEGF expression and stimulation of bone formation. The extent of the outgrowth was observed to be generally associated with better restoration of the junctional fibrocartilage zone. However, substantiation on this observation is needed by the ongoing histomorphometrical analysis. The enlargement of the remaining patella after partial patellectomy might reduce the stress to the patellofemoral joint, potential stress-induced deterioration of its articular cartilage and improvement of knee joint function. As LIPUS is a non-invasive and non-destructive approach, it may have clinical potentials for earlier and active rehabilitation of injuries involving BT junction repair.