The capsuloligamentous complex is a key inducer of cartilage degeneration in the ratstronger driver than the long head of the biceps tendon in a rotator cuff tear arthropathy rat model

Kohei Uekama[1,4], Tomohiro Iuchi[1,2], Toshiro Ijuin[1], Hiroki Tawaratsumida[1], Takayuki Ide[1], Kento Shimanoe[1], Yusuke Masuda[1], Shingo Maeda[4], Noboru Taniguchi[1,2,3,4]

[1]Department of Orthopaedic Surgery, [2]Department of Medical Joint Materials, [3]Department of Locomotory Organ Regeneration, [4]Department of Bone and Joint Medicine, Kagoshima University, Kagoshima, Japan

Email: kamabiscus814@gmail.com

Disclosures: Kohei Uekama (N), Tomohiro Iuchi (N), Toshiro Ijuin (N), Hiroki Tawaratsumida (N), Takayuki Ide(N), Kento Shimanoe(N), Yusuke Masuda (N), Shingo Maeda (N), Noboru Taniguchi (N)

INTRODUCTION

Rotator cuff tear arthropathy (CTA) is a type of shoulder osteoarthritis (OA) that can develops after rotator cuff tears and is characterized by subchondral collapse and deformity of the humeral head with synovial fibrous proliferation. CTA may develop as early as 5 years after a rotator cuff tear and is marked characterized by substantial deformation of the glenohumeral joint, including subchondral bone collapse in the humeral head, along with pannus-like fibrous cells and bone loss[1]. Previously reported murine CTA models required approximately 40 weeks (equivalent to about 30 years in humans) to develop arthropathic changes, and the resulting phenotype was only mild, making it difficult to consider them reflective of the clinical condition.Existing rat models often require long observation periods yet rarely reproduce humeral head collapse. In our laboratory, Wwe created a modified model that induces CTA-like changes in four 4 weeks (equivalent to approximately three 3 years in humans) and also shows subchondral bone collapse by simultaneously removing the superior part of joint capsule and long head of the biceps brachii tendon (LHB) in addition to the RCT[2]rotator cuff resection[2,3]. However, it remains unclear which of the joint capsule and LHB is more important crucial for the mCTA model creationprogression.[,] This study aimed to assess the contribution of each additional procedure to mCTA changes by applying them individually.and this study aimed to clarify this practical question at the preclinical level: between the capsule and the LHB, which structure more strongly drives the phenotypes of cartilage degeneration, subchondral bone loss, and synovial inflammation in CTA?

METHODS

Twelve-week male Sprague–Dawley rats were assigned to five 5 groups (n=6 per group[).:] Sham[-], RCT (supraspinatus + infraspinatus resection[),], RCT+LHB (biceps tenotomy[),] RCT+Capsule (anteroinferior-to-posterior capsular resection),[,] and mCTA (RCT+LHB+Capsule) (Fig. 1). Endpoints at 4 weeks included histology of articular cartilage with H&E, Alcian blue, and Safranin O, and scoring by Murine Shoulder Arthritis Score (MSAS) and Mankin score. Subchondral bone was evaluated by histomorphometry (bone volume: BV/TV, osteoclast number: Oc.N/BS). IL-1β and MMP-13 Iimmunohistochemistry for IL-1β and MMP-13 was performed in synovium and cartilage. Nonparametric tests were used for between-group comparisons, and effect sizes (Cohen's d) were calculated to contextualize clinical magnitude. Male animals were used to limit hormonal variability, and validation in females is planned.

RESULTS

Cartilage: In terms of cartilage OA changes, Compared with RCT alone, capsule resection in addition to RCT aggravated MSAS and Mankin scores more severely than LHB resectionadding capsule resection worsened MSAS/Mankin more than adding LHB; the worst degeneration occurred with the combined resection (mCTA) (Fig. 2).

Subchondral In terms of Ssubchondral bone changes,[:] RCT alone caused a dramatic reduction in subchondral bone mass, and the addition of LHB or capsule resection did not result in any further significant decreaseBV/TV decreased with RCT and declined further only in mCTA. Osteoclast numbers mirrored the changes in BV/TV, showing a marked increase with RCT alone, and additional LHB or capsule resection did not further elevate them. However, simultaneous addition of LHB and capsule resection (mCTA) led to a coordinated decrease in bone mass and an increase in osteoclasts Oc.N/BS increased in a mirror-image manner to BV/TV (Fig. 2). The expression of IL−1β and MMP−13 paralleled the changes in Mankin and MSAS scores, correlating with OA progression

Inflammation/catabolism: IL-1β and MMP-13 signals increased in synovium (and cartilage) with either LHB or capsule resection, consistently stronger with capsule (Fig. 3).

書式を変更：フォント：太字（なし）

書式変更：p1，1 行の文字数を指定時に右のインデント幅を自動調整しない，日本語と英字の間隔を自動調整しない，日本語と数字の間隔を自動調整しない，タブ位置：1.13 字，左揃え

DISCUSSION

Our fIindings indicate that capsular disruption is the dominant driver of cartilage degeneration. The Capsuloligamentous capsuloligamentous Complex complex provides a "—"reverse trampoline"—" effect, preventing the humeral head from making contact with the undersurface of the acromion[4]. LHB resection did not lead to as much OA progression as capsule resection, suggesting that the capsule plays a more important role in humeral head stabilityCapsular resection had a greater impact on OA progression in humeral cartilage. The LHB contributes to dynamic stability but, by itself, is less protective for cartilage. In the subchondral bone, RCT alone likely caused a substantial bone loss approaching that seen in mCTA, due to a marked reduction in the compressive mechanical stress on the humeral head. This suggests that the compressive mechanical stress exerted by the rotator cuff is important for maintaining humeral head bone mass.For bone, RCT initiates an absorption-biased remodeling that becomes most pronounced when both capsular restraint and LHB-based dynamic stability are absent (mCTA), explaining the two-stage pattern (initial drop with RCT, largest drop with combined lesions).

SIGNIFICANCE/CLINICAL RELEVANCE

~~Clinically,~~ Clinically, repairing the torn capsuloligamentous complex alongside rotator cuff tears is considered important for preventing CTA. In this study, the significant role of the capsule in preventing CTA after RCT was experimentally demonstrated. Additionally, it was shown that the compressive traction exerted by the rotator cuff is important for maintaining humeral head bone mass.~~in irreparable RCT, preserving or reconstructing the capsule/capsuloligamentous complex is a rational strategy for cartilage protection, while controlling synovitis and the IL-1β/MMP-13 axis represents a plausible therapeutic target. The work clarifies what is protected by which structure (cartilage vs. bone vs. inflammation) and provides a focused foundation for future interventions.~~

REFERENCES: 1) Neer CS 2nd, Craig EV, Fukuda H. J Bone Joint Surg Am., 65:1232-1244, 1983; 2) Ijuin T., et al., Osteoarthritis Cartilage Open., 5:100389, 2023; 3) Tawaratsumida H., et al., Osteoarthritis Cartilage., S1063-4584(24)01354-2, 2024; 4) Adams CR., et al., Arthroscopy., 32:2628-2637, 2016.~~.~~

IMAGES: