# APKASS Consensus Statement on Chronic Syndesmosis Injury, Part 2

## Indications for Surgical Treatment, Arthroscopic or Open Debridement, and Reconstruction Techniques of Suture Button and Screw Fixation

Hiroaki Kurokawa,* MD, PhD, Hongyun Li,† MD, PhD, Chayanin Angthong,‡§ MD, PhD, Yasuhito Tanaka,* MD, PhD, Yujie Song,† MD, Zhongmin Shi,‖ MD, PhD, Samuel K.K. Ling,¶ MBChB, Patrick Yung,¶ MBChB, Seung Hwan Han,# MD, PhD, Yinghui Hua,† MD, PhD, Chen Jiao,** MD, PhD, Jianchao Gui,†† MD, PhD, and Qi Li,†† MD, PhD, on behalf of the APKASS Foot and Ankle Committee

**Background:** The indications for surgical treatment of chronic syndesmosis injury are challenging for many orthopaedic clinicians, as there is no international consensus on the optimal management of these injuries.

**Purpose:** An international group of experts representing the field of sports injuries in the foot and ankle area was invited to collaboratively advance toward consensus opinions based on the best available evidence regarding chronic syndesmosis injury. All were members of the Asia-Pacific Knee, Arthroscopy and Sports Medicine Society (APKASS).

**Study Design:** Consensus statement.

**Methods:** From November to December 2020, a total of 111 international experts on sports medicine or ankle surgery participated in a 2-stage Delphi process that included an anonymous online survey and an online meeting. A total of 13 items with 38 statements were drafted by 13 core authors. Of these, 9 items with 17 clinical questions and statements were related to indications for surgical treatment, arthroscopic versus open debridement, and suture button versus screw fixation reconstruction techniques and are presented here. Each statement was individually presented and discussed, followed by a general vote. The strength of consensus was characterized as follows: consensus, 51% to 74%; strong consensus, 75% to 99%; and unanimous, 100%.

**Results:** Of the 17 questions and statements, 4 achieved unanimous support, 11 reached strong consensus, and 2 reached consensus.

**Conclusion:** This APKASS consensus statement, developed by international experts in the field, will assist surgeons and physical therapists with surgical indications and techniques for chronic syndesmosis injury.

**Keywords:** syndesmosis injury; ankle; surgical indication; surgical treatment; consensus

The syndesmosis is a fibrous joint that contributes to ankle stability. The diagnosis and treatment of chronic syndesmosis injuries have been challenging for many foot and ankle surgeons. Misdiagnosis of syndesmosis instability may cause residual pain and, in the long term, ankle osteoarthritis. Chronic syndesmosis injuries are defined as injuries that have been present for >6 months after trauma.[6,27]

Debridement of injured syndesmosis was first performed with or without arthroscopy in accordance with the surgical techniques for chronic syndesmosis injury. Syndesmosis was then stabilized with a suture button or screw. Many studies have been published on the surgical indications and techniques for syndesmosis injuries; however, optimal guidelines with an international consensus are not available. The indications and techniques, such as suture button or screw fixation and arthroscopic or open debridement, depend on the surgeon's preference and experience.

Experts from the Asia-Pacific Knee, Arthroscopy and Sports Medicine Society (APKASS) convened to develop expert- and evidence-based consensus statements in order to assist surgeons and physical therapists in the management of this challenging disorder. The purpose of this article was to report the results of discussions regarding

The Orthopaedic Journal of Sports Medicine, 9(6), 23259671211021063
DOI: 10.1177/23259671211021063

indications for surgical treatment, arthroscopic versus open debridement, and suture button versus screw fixation reconstruction techniques that took place at the 2020 APKASS international consensus meeting on chronic syndesmosis injury.

## METHODS

A core group of 13 authors drafted and refined 13 items consisting of 38 clinical questions and statements, which were then assigned to at least 1 of the authors to research and summarize the current available evidence. Our consensus methodology was designed using a 2-stage Delphi process, which included an online survey (November 20, 2020; stage 1) and an online meeting (December 20, 2020; stage 2). The final document that was sent out for stage 1 of the consensus process featured 8 items and 29 statements (available as Supplemental Material). Each statement was individually presented and discussed, followed by a general vote.

### Stage 1

We invited 21 experts to fill out the online questionnaire (www.surveymonkey.com). For each of the 29 statements, the experts could respond with *agree*, *disagree*, or *don't know/not sure*, as well as submit optional comments. One author (Y.S.) compiled the survey results and shared them with the core author group for analysis. Statements that achieved consensus (67%, or a two-thirds supermajority) were not discussed further. Consensus was reached on 19 of the 29 initial statements.

### Stage 2

Besides the core group of 13 authors, 98 experts in the field attended the online meeting via Zoom. The remaining 5 items (9 statements) underwent voting per stage 1, then all statements that did not achieve consensus after the online survey were displayed and discussed using PowerPoint (Microsoft Corp) by each responsible author, after which 1 of the following 2 steps were taken:

*Step 1.* If inconsistent opinions were proposed and supported by 2 additional participants during the discussion, modification was required and an amendment motion was made. The statement was modified if the proportion of votes in favor of doing so was $\geq$67%.

*Step 2.* When the participating 111 experts did not propose any further modifications, the group voted for or against the statement. If the proportion of favorable votes was $\leq$50%, the statement was excluded from the overall consensus statement. If the proportion of favorable votes was >50%, the statement was passed and was included in the overall consensus statement. The strength of consensus was characterized as follows: 51% to 74% indicated consensus; 75% to 99% indicated strong consensus; and 100% indicated unanimous consensus.

A draft of the manuscript was circulated to all 13 core authors, and all comments/edits were incorporated.

## RESULTS

Of the 17 total clinical questions in this section, 4 achieved unanimous support, 11 reached strong consensus, and 2 reached consensus.

**Item 5: Indications for Surgery**

*Question 1:* When should the patient be stabilized surgically?

*Response:* Surgical treatment should be considered whenever syndesmosis instability is diagnosed with imaging or arthroscopy.

*Vote:* Agree 100% (unanimous)

*Question 2:* Is early stabilization recommended to return to sports for athletes?

*Response:* It is not for all but for some athletes who hope for early return to play, early arthroscopic assessment (with or without stabilization) may be preferred.

*Vote:* Agree 81.8% (strong consensus)

*Question 3:* What are the indications for surgery in patients with generalized joint hypermobility (GJH)?

*Response:* We need further study for patients with GJH, and we need to take care when we perform the reconstruction.

*Vote:* Agree 95.5% (strong consensus)

**Item 6: Is Arthroscopic/Open Debridement Necessary for Chronic Syndesmosis Injury?**

*Question 1:* Is scar tissue one of the sources of the clinical symptoms in patients with chronic syndesmosis injury?

[§]Address correspondence to Chayanin Angthong, MD, PhD, Division of Digital and Innovative Medicine, Faculty of Medicine, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand (email: chatthara@yahoo.com).

[*]Department of Orthopedic Surgery, Nara Medical University, Nara, Japan.

[†]Department of Sports Medicine, Huashan Hospital, Fudan University, Shanghai, China.

[‡]Division of Digital and Innovative Medicine, Faculty of Medicine, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand.

[‖]Department of Orthopedics, Shanghai Sixth People Hospital, Jiaotong University, Shanghai, China.

[¶]Department of Orthopaedics & Traumatology, Prince of Wales Hospital, The Chinese University of Hong Kong, Hong Kong, China.

[#]Department of Orthopaedic Surgery, Gangnam Severance Hospital, Yonsei University College of Medicine, Seoul, Republic of Korea.

[**]Department of Sports Medicine, Peking University Third Hospital, Institute of Sports Medicine of Peking University, Beijing Key Laboratory of Sports Injuries, Beijing, China.

[††]Department of Sports Medicine, Nanjing First Hospital, Nanjing, China.

Final revision submitted April 10, 2021; accepted April 20, 2021.

H.K. and H.L. contributed equally to this work.

C.A. and Y.T. contributed equally to this work.

*Response:* Scar tissue in the distal tibiofibular joint is one of the sources of clinical symptoms, including pain, swelling, stiffness, and limited dorsiflexion of the ankle joint in patients with chronic syndesmosis injury.
*Vote:* Agree 90.5% (strong consensus)

*Question 2:* Are there any positive signs during physical examination for the evaluation of scar tissue in patients with chronic syndesmosis injury?
*Response:* During physical examination, persistent tenderness and swelling in the anterolateral aspect of the ankle joint syndesmosis combined with squeeze test or external rotation test indicates the presence of scar tissue in syndesmosis.
*Vote:* Agree 94.4% (strong consensus)

*Question 3:* Can we evaluate syndesmosis scar tissue by image examination?
*Response:* The size and location of scar tissue can be evaluated by preoperative magnetic resonance imaging (MRI).
*Vote:* Agree 71.4% (consensus)

*Question 4:* Is debridement necessary?
*Response:* Debridement can achieve better reduction and improve clinical outcomes.
*Vote:* Agree 81.0% (strong consensus)

*Question 5:* How should debridement be performed?
*Response:* The technique of syndesmosis debridement can be performed as follows: first, the medial gutter is debrided. Second, the syndesmosis is debrided from the syndesmosis and down to the ankle joint until the articular cartilage of the talar dome is visible.
*Vote:* Agree 90.5% (strong consensus)

*Question 6:* Should we choose arthroscopic or open debridement?
*Response:* There is no consistent conclusion for the debridement technique. We can choose either arthroscopic or open debridement during the operation.
*Vote:* Agree 90.5% (strong consensus)

*Question 7:* Is debridement alone enough?
*Response:* Syndesmosis debridement alone can achieve good outcomes for patients with no obvious medial ankle instability and lateral displacement of the talus and for patients with separation <5 mm.
*Vote:* Agree 66.7% (consensus)

**Item 7: How Should Screw Fixation Be Chosen?**
*Response 1:* Regarding the selection of screw size for the surgical fixation of syndesmotic diastasis, both 3.5-mm and 4.5-mm cortical screws exhibit similar biomechanical characteristics and there does not seem to be any superiority of the 4.5-mm over the 3.5-mm cortical screw in fixation of the syndesmosis. The decision appears to depend on surgeons' experience and preference.
*Vote:* Agree 100% (unanimous)

*Response 2:* The use of 4.5-mm screw on 4 cortices gives considerable support against shear stresses applied to the distal syndesmosis during weightbearing.
*Vote:* Agree 88.2% (strong consensus)

*Response 3:* Two screws should be used in cases of unstable injury with a high degree of instability, such as high fibular fractures (Maisonneuve fracture).
*Vote:* Agree 82.4% (strong consensus)

**Item 8: Suture Button vs Screw Fixation**
*Statement:* Suture buttons generally provide less rigid fixation compared with screw fixation, especially in sagittal motion, unless a double divergent pattern is utilized. However, clinical translation of this biomechanical finding is equivocal. Suture buttons theoretically negate the need for routine implant removal, but there have been reports of its causing skin impingement.
*Vote:* Agree 85.7% (strong consensus)

**Item 9: Indications, Methods, and Outcomes for Reconstruction**
*Question 1:* Is it necessary to reconstruct each ligament? Is only reconstruction of the anterior inferior tibiofibular ligament (AITFL) enough?
*Response:* We need to diagnose the injured ligaments preoperatively or intraoperatively and to perform appropriate reconstruction simultaneously.
*Vote:* Agree 100% (unanimous)

*Question 2:* Do suture button constructs sufficiently restore ankle stabilization?
*Response:* With a clamp to maintain syndesmosis reduction, 2 divergent suture buttons tightened maximally by hand and the AITFL augmentation with suture tape is ideal to restore syndesmosis stability.
*Vote:* Agree 85.7% (strong consensus)

*Question 3:* Is it necessary to repair the deltoid ligament?
*Response:* If the medial instability is combined, deltoid ligament repair or reconstruction with syndesmosis reconstruction may accelerate postoperative rehabilitation.
*Vote:* Agree 100% (unanimous)

## DISCUSSION

A total of 17 statements on the indications for surgical treatment, arthroscopic or open debridement, reconstruction techniques of the suture button, and screw fixation of chronic syndesmosis injury reached a consensus. Of these, 4 achieved unanimous support, 11 reached strong consensus, and 2 reached consensus.

The syndesmosis complex consists of 4 ligaments. The AITFL (35%) and deep posterior inferior tibiofibular ligament (PITFL) (33%) contribute the most to ankle stability, followed by the interosseous ligament (IOL) (22%) and superficial posterior tibiofibular ligament (9%).[16] The syndesmosis is commonly injured with the AITFL first.[1] The AITFL is important in providing resistance to external rotation and posterior translation of the fibula. In contrast, the PITFL is an important structure involved in controlling internal rotation.[4]

Regarding surgical indications, classifications such as the West Point Ankle Grading System have attempted to categorize the degree of injury and to use this to

recommend management.[8] According to this classification, grade 1 injuries with stable syndesmosis are treated conservatively, and grade 3 injuries with complete disruption of the syndesmosis and instability require surgical stabilization.[6] However, intermediate grade 2 injuries have been poorly defined because of the difficulty of diagnosis. This difficulty in diagnosis leads to more time spent deciding on surgical indications. In a previous report, the mean time between injury and surgical treatment was 18.2 months (range, 1.5-252 months).[11] MRI is one of the most reliable methods used to prevent misdiagnosis. The "lambda sign," that is, fluid making a contiguous signal from the mortise up through the syndesmosis and posterior malleolus bone edema, has been shown to yield high sensitivity for syndesmosis complex injury.[21,22] However, MRI findings become less reliable with time. The prevalence of ligament injuries decreases significantly over time.[10] If a syndesmosis injury is suspected, early MRI assessment, recommended within 12 weeks, is used to help determine stable versus unstable injuries.[21]

The indication as to whether athletes might benefit from early stabilization or are at risk of developing later symptoms from a subtle syndesmotic instability currently depends on the individual interpretation of the severity of the injury. This is done through a combination of meticulous history taking, clinical examination findings, imaging, and personal assessment of the level of activity and expectations of the athlete.[2] Recovery from syndesmosis injury generally takes longer than lateral ankle sprains such as anterior talofibular ligament and calcaneofibular ligament injuries.[28] Early arthroscopic assessment with or without syndesmosis stabilization has therefore been advocated for elite athletes with severe syndesmosis injury when dynamic instability is suspected, so as to avoid later symptoms and a delayed return to play.[2]

GJH is defined merely as hyperextensibility of the synovial joints with the ability to extend, passively and/or actively, beyond the normal physiological range of motion. The prevalence of GJH ranges from 2% to 57%, depending on the definition and methods used.[24] There are no reports about the surgical outcomes of syndesmosis reconstruction in patients with GJH. However, for patients with lateral ankle instability, ligamentous laxity is a risk factor for inferior outcome.[13] Further studies are needed for patients with GJH, and care should be taken when performing the reconstruction.

The gold standard for the diagnosis of syndesmosis injuries is arthroscopy. Most surgical techniques are performed using arthroscopy. Syndesmosis adhesions or scar tissue has been implicated as a source of chronic pain in syndesmosis injury; this was because of the lack of congruency of the syndesmosis or along the medial gutter of the ankle.[7,18] The nonphysiological tissue limits ankle motion and results in impingement of the hypertrophied tissue against the lateral talar dome in dorsiflexion.[19] Clanton et al[3] found that prominent synovial recess scarring and synovitis were readily apparent on preoperative MRI in patients with chronic syndesmotic injury.

Studies have reported better syndesmosis reduction after debridement.[10] Resection of the injured IOL and the chondral lesion significantly improves patients' outcomes and restores their ability to return to their preoperative activities.[10,17] Syndesmosis debridement techniques have been reported.[7,29] The syndesmotic region is often filled with posttraumatic scar tissue. First, the medial gutter is debrided either arthroscopically or via a medial miniarthrotomy. This is because scar tissue is frequently present in the medial region, which prevents talus reduction in the mortise. Second, the syndesmosis is carefully debrided down to the ankle joint until the articular cartilage of the talar dome is visible when looking distally between the fibula and tibia.[7,29] Lui[15] recommended that the scar tissue around the syndesmosis be debrided and the congruity of the syndesmosis be assessed. Mostly, it is not easy to mobilize the syndesmosis adequately to achieve anatomical reduction using arthroscopic debridement alone. Moreover, unlike acute syndesmosis diastasis, arthroscopic instruments can barely be inserted into the syndesmosis in case of a chronic syndesmosis injury. Therefore, extra-articular syndesmosis endoscopy should be performed to achieve complete soft tissue release in case of syndesmosis injury.[15] In contrast, Espinosa et al[7] demonstrated that the anterolateral distal syndesmosis space could be visualized arthroscopically. However, given the amount and density of the scar tissue, open debridement is mostly preferred. A distal syndesmosis is aggressively debrided to remove all scars and soft tissue.[7]

Han et al[10] compared the differences between patients with and without transfixation syndesmosis after arthroscopic debridement and concluded that arthroscopic debridement alone can be recommended if chronic syndesmosis injury is not combined with medial ankle instability and lateral displacement of the talus. Turky et al[26] demonstrated a new arthroscopic grading system for syndesmotic injuries. In their study, syndesmosis width was classified during arthroscopic evaluation as grade 0 ($\leq$2 mm; normal), grade 1 ($>$2 to 4 mm), and grade 2 ($\geq$5 mm). They suggested that patients with grade 0 or grade 1 injuries do not need special intervention.[26]

Screw fixation and suture buttons are the most common methods used to stabilize syndesmosis. Traditionally, screw fixation has been performed. The selection of screw size appears to depend on the surgeon's experience and preference. The use of a 4.5-mm screw on the 4 cortices provides considerable support against shear stresses. Two screws should be used for unstable injuries.

In contrast, the suture button generally permits anatomical syndesmosis motion compared with screw fixation.[25] In terms of rotational stability, the results were comparable between single 3.5-mm screws, single suture buttons, and double divergent suture buttons. However, sagittal stability is lower with the single suture button.[23] Clanton et al[5] reported that 2 divergent suture buttons were beneficial for 2 reasons: First, if 1 of the devices loosened or failed, there would still be a backup device for stability; and second, if 2 devices were placed in a divergent orientation and were cinched down in an orderly, alternating fashion, this would allow the fibula to settle properly within the incisura, potentially aiding in the prevention of malreduction. No significant differences were observed in the American

Orthopedic Foot & Ankle Society score. Adequacy reduction is more important than the method of fixation.[20]

Regarding surgical techniques, the suture button consists of a knotless device inserted per manufacturer guidelines and manually tightened to the maximum. A large reduction clamp should be used to maintain syndesmosis reduction during tunnel drilling and insertion of each device.[9] Previous studies concluded that 1 or 2 suture buttons were not able to restore stability in both the coronal and the sagittal planes compared with the uninjured syndesmosis.[5,9,23,25] Goetz et al[9] reported applying syndesmosis compression via 133 N (30 lb) suture tension. Shoji et al[23] concluded that AITFL augmentation using a suture tape that was oriented in the same direction as the AITFL fibers functioned as a substitute for the injured AITFL. Suture button with suture tape augmentation deserves consideration as a clinical tool for syndesmosis injuries.

The mechanism of deltoid ligament injury is similar to syndesmosis injury, involving external rotation of the foot or eversion of the talus within the ankle mortise. Syndesmosis injury with deltoid ligament injury usually results in significant ankle mortise instability.[14] Suture tape repairs of the AITFL and deep deltoid ligament have been required to improve rotational stability when a flexible transsyndesmosis device was used.[9] Repair of the deltoid ligament may be beneficial to patients who desire early weightbearing.[12]

## CONCLUSION

The 9 items with 17 clinical questions and statements of this APKASS consensus statement focused on the surgical indications and surgical techniques concerning chronic syndesmosis injury and may be beneficial for clinicians in the management of this challenging disorder.

## ACKNOWLEDGMENT

The authors acknowledge the following for their participation: Jun Chen, MD (Dongyang People's Hospital, Wenzhou Medical University, China); Bo Feng, MD (The Third Clinical Medical College of Inner Mongolia Medical University, China); Fulong Gu, MD (Nantong Traditional Chinese Medicine Hospital, China); Xueping Gu, MD (The Affiliated Suzhou Hospital of Nanjing Medical University, China); Qinglin Han, MD (The Affiliated Hospital of Nantong University, China); Yuefeng Hao, MD (The Affiliated Suzhou Hospital of Nanjing Medical University, China); Jiang Heng, MD (Tianxiang East Hospital, China); Dong Jiang, MD, PhD (Peking University Third Hospital, China); Dongliang Shi, MD (Yangzhi Rehabilitation Hospital, Tongji University School of Medicine, China); Jin Su Kim, MD (Sejong Sports Medicine and Sports Performance Center, Republic of Korea); Hak Jun Kim, MD (Korea University College of Medicine, Republic of Korea); Jiaping Lan, MD (Suining Central Hospital, China); Lei Li, MD (Suining Central Hospital, China); Fei Li, MD (The 1st Hospital of Tsinghua University, China); Ding Li, MD (The 2nd Xiangya Hospital, Center South University, China); Yi Liu, MD (Guangdong Provincial Hospital of Traditional Chinese Medicine, China); Wei Luo, MD (Longkou Traditional Chinese Medicine Hospital, China); Kwang Hwan Park, MD (Yonsei University, Korea); Jae Yong Park, MD (Hallym University Sacred Heart Hospital, Republic of Korea); Yan Qi, MD (Yangzhi Rehabilitation Hospital, Tongji University School of Medicine, China); Yuanyuan Qian, MD (The First People's Hospital of Changshu City, China); Zilong Sheng, MD (Beijing Huairou Hospital, China); Bin Song, MD (Sun Yat-Sen Memorial Hospital, China); Tong Su, MD (Peking University Third Hospital, China); Xu Tao, MD (Luzhou Traditional Chinese Medicine Hospital, China); Nattachai Thaengthong, MD (Sakaeo Crown Prince Hospital, Thailand); Yiran Wang, MD (Huashan Hospital, Fudan University, China); Shaoshan Wang, MD (Shandong Provincial Hospital of Traditional Chinese Medicine, China); Bin Wu, MD (Shanghai Jiangong Hospital, China); Hansong Xia, MD (The 3rd Xiangya Hospital, Central South University, China); Qian Xu, MD (910th Hospital of PLA, China); Guoyong Yang, MD (No. 1 Orthopedics Hospital of Chengdu, China); Zhengshuang Yue, MD (Xiaoshan TCM Hospital, China); Kexiang Zhang, MD (The 3rd Xiangya Hospital, Central South University, China); Xiaoming Zhao, MD (The People's Hospital of Lishui District, China); Yuan Zhu, MD (Shanghai Ruijin Hospital Foot and Ankle Center, Shanghai Jiaotong University, China); Chuan He, MD (The First Affiliated Hospital of Kunming Medical University, China); Qianru Li, MD (Huashan Hospital, Fudan University, China); Junyoung Lee, MD (Chosun University Hospital, Republic of Korea); Kyoung Min Lee, MD (Seoul National University Bundang Hospital, Republic of Korea); Min Luo, MD (Dongyang Traditional Chinese Medicine Hospital, China); Haidong Ma, MD (Tangshan Second Hospital, China); Shui Man, MD (Queen Elizabeth Hospital, Hong Kong, China); Young Koo Lee, MD (Soonchunhyang University Bucheon Hospital, Republic of Korea); Yanming Liu, MD (Luzhou Traditional Chinese Medicine Hospital, China); Eva Au, MD (Queen Elizabeth Hospital, Hong Kong, China); Angela Ho, MD (Chitwan Medical College, Nepal); Cong Wang, MD (Shuguang Hospital, China); Jaeho Cho, MD (Chuncheon Sacred Heart Hospital, Korea); Jungwoo Choi, MD (Korea University Guro Hospital, Republic of Korea); Satetha Vasaruchapong, MD (Chakri Naruebodindra Medical Institute, Thailand); Chan Kang, MD (Chungnam National University Hospital, Republic of Korea); Qiang Hua, MD (Affiliated Sports Hospital of Chengdu Sport University, China); Hyun Woo Park, MD (Dankook University Hospital, Republic of Korea); Kwai Ming Siu, MD (The Hong Kong Orthopaedic Association, Hong Kong, China); Yeonjoo Jeong, MD (Chosun University Hospital, Republic of Korea); Changuoung Jung, MD (Leechuntaek Hospital, Republic of Korea); Jiao Sha, MD (The First People's Hospital of Taicang, China); Feng Tian, MD (Xi'an Honghui Hospital, China); Yunfeng Shen, MD (Huashan Hospital, Fudan University, China); Pisut Tuntanatipchai, MD (Sakaeo Crown Prince Hospital, Thailand); Guixin Wang, MD (Tianjin Hospital, China); Hui Zhao, MD (Beijing Chaoyang Hospital, China); Meng Shi, MD (Shuguang

Hospital, China); Zhiwei Zhang, MD (Yueyang Second People's Hospital, China); Songwut Thitiboonsuwan, MD (Navamindradhiraj University, Thailand); Min Zhu, MD (920th Hospital of PLA, China); Suwimol Prusmetikul, MD (Ramathibodi Hospital, Mahidol University, Thailand).

Supplemental material for this article is available at http://journals.sagepub.com/doi/suppl/10.1177/23259671211021063.

## REFERENCES

1. Boytim MJ, Fischer DA, Neumann L. Syndesmotic ankle sprains. *Am J Sports Med*. 1991;19(3):294-298.
2. Calder JD, Bamford R, Petrie A, McCollum GA. Stable versus unstable grade II high ankle sprains: a prospective study predicting the need for surgical stabilization and time to return to sports. *Arthroscopy*. 2016;32(4):634-642.
3. Clanton TO, Ho CP, Williams BT, et al. Magnetic resonance imaging characterization of individual ankle syndesmosis structures in asymptomatic and surgically treated cohorts. *Knee Surg Sports Traumatol Arthrosc*. 2016;24(7):2089-2102.
4. Clanton TO, Williams BT, Backus JD, et al. Biomechanical analysis of the individual ligament contributions to syndesmotic stability. *Foot Ankle Int*. 2017;38(1):66-75.
5. Clanton TO, Whitlow SR, Williams BT, et al. Biomechanical comparison of 3 current ankle syndesmosis repair techniques. *Foot Ankle Int*. 2016;38(2):200-207.
6. Colcuc C, Fischer S, Colcuc S, et al. Treatment strategies for partial chronic instability of the distal syndesmosis: an arthroscopic grading scale and operative staging concept. *Arch Orthop Trauma Surg*. 2016;136(2):157-163.
7. Espinosa N, Smerek JP, Myerson MS. Acute and chronic syndesmosis injuries: pathomechanisms, diagnosis and management. *Foot Ankle Clin*. 2006;11(3):639-657.
8. Gerber JP, Williams GN, Scoville CR, et al. Persistent disability associated with ankle sprains: a prospective examination of an athletic population. *Foot Ankle*. 1998;19:653-660.
9. Goetz JE, Davidson NP, Rudert MJ, Szabo N, Karam MD, Phisitkul P. Biomechanical comparison of syndesmotic repair techniques during external rotation stress. *Foot Ankle Int*. 2018;39(11):1345-1354.
10. Han SH, Lee JW, Kim S, Suh JS, Choi YR. Chronic tibiofibular syndesmosis injury: the diagnostic efficiency of magnetic resonance imaging and comparative analysis of operative treatment. *Foot Ankle Int*. 2007;28(3):336-342.
11. Krähenbühl N, Weinberg MW, Hintermann B, Haller JM, Saltzman CL, Barg A. Surgical outcome in chronic syndesmotic injury: a systematic literature review. *Foot Ankle Surg*. 2019;25(5):691-697.
12. LaMothe J, Baxter JR, Gilbert S, Murphy CI, Karnovsky SC, Drakos MC. Effect of complete syndesmotic disruption and deltoid injuries and different reduction methods on ankle joint contact mechanics. *Foot Ankle Int*. 2017;38(6):694-700.
13. Li X, Lin TJ, Busconi BD. Treatment of chronic lateral ankle instability: a modified Broström technique using three suture anchors. *J Orthop Surg Res*. 2009;4:41.
14. Lin CF, Gross ML, Weinhold P. Ankle syndesmosis injuries: anatomy, biomechanics, mechanism of injury, and clinical guidelines for diagnosis and intervention. *J Orthop Sports Phys Ther*. 2006;36(6):372-384.
15. Lui TH. Arthroscopic arthrodesis of the distal tibiofibular syndesmosis. *J Foot Ankle Surg*. 2015;54(5):953-957.
16. Ogilvie-Harris DJ, Reed SC, Hedman TP. Disruption of the ankle syndesmosis: biomechanical study of the ligamentous restraints. *Arthroscopy*. 1994;10(5):558-560.
17. Ogilvie-Harris DJ, Reed SC. Disruption of the ankle syndesmosis: diagnosis and treatment by arthroscopic surgery. *Arthroscopy*. 1994;10(5):561-568.
18. Peña FA, Coetzee JC. Ankle syndesmosis injuries. *Foot Ankle Clin*. 2006;11(1):35-50.
19. Pritsch M, Lokiec F, Sali M, Velkes S.Adhesions of distal tibiofibular syndesmosis. A cause of chronic ankle pain after fracture. *Clin Orthop Relat Res*. 1993;289:220-222.
20. Rammelt S, Obruba P. An update on the evaluation and treatment of syndesmotic injuries. *Eur J Trauma Emerg Surg*. 2015;41(6):601-614.
21. Randell M, Marsland D, Ballard E, Forster B, Lutz M. MRI for high ankle sprains with an unstable syndesmosis: posterior malleolus bone oedema is common and time to scan matters. *Knee Surg Sports Traumatol Arthrosc*. 2019;27(9):2890-2897.
22. Ryan LP, Hills MC, Chang J, Wilson CD. The lambda sign: a new radiographic indicator of latent syndesmosis instability. *Foot Ankle Int*. 2014;35:903-908.
23. Shoji H, Teramoto A, Suzuki D, et al. Suture-button fixation and anterior inferior tibiofibular ligament augmentation with suture-tape for syndesmosis injury: a biomechanical cadaveric study. *Clin Biomech (Bristol, Avon)*. 2018;60:121-126.
24. Sundemo D, Hamrin Senorski E, Karlsson L, et al. Generalised joint hypermobility increases ACL injury risk and is associated with inferior outcome after ACL reconstruction: a systematic review. *BMJ Open Sport Exerc Med*. 2019;5(1):e000620.
25. Teramoto A, Suzuki D, Kamiya T, Chikenji T, Watanabe K, Yamashita T. Comparison of different fixation methods of the suture-button implant for tibiofibular syndesmosis injuries. *Am J Sports Med*. 2011;39(10):2226-2232.
26. Turky M, Menon KV, Saeed K. Arthroscopic grading of injuries of the inferior tibiofibular syndesmosis. *J Foot Ankle Surg*. 2018;57(6):1125-1129.
27. Vopat ML, Vopat BG, Lubberts B, DiGiovanni CW. Current trends in the diagnosis and management of syndesmotic injury. *Curr Rev Musculoskelet Med*. 2017;10(1):94-103.
28. Wake J, Martin KD. Syndesmosis injury from diagnosis to repair: physical examination, diagnosis, and arthroscopic-assisted reduction. *J Am Acad Orthop Surg*. 2020;28(13):517-527.
29. Yasui Y, Takao M, Miyamoto W, Innami K, Matsushita T. Anatomical reconstruction of the anterior inferior tibiofibular ligament for chronic disruption of the distal tibiofibular syndesmosis. *Knee Surg Sports Traumatol Arthrosc*. 2011;19(4):691-695.