Guidelines for the Diagnosis and Treatment of Ulnar Impaction Syndrome (2024)

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J Wrist Surg 2025;14:2–13.

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Abstract

Background Ulnar impaction syndrome (UIS), also known as ulnar impaction or ulnar abutment, is a degenerative condition causing pain on the ulnar side of the wrist. It can lead to wrist bone necrosis, resulting in wrist joint stability disruption and a significant wrist function impairment. The global understanding of this condition varies, contributing to substantial differences in clinical outcomes.

Purposes This paper underscores the necessity of developing evidence-based clinical guidelines for UIS to guide clinicians in their diagnostic and therapeutic approaches.

Materials and Methods In collaboration with the Asian Pacific Wrist Association, a team of experts from various fields within the Hand Surgery Department at Huashan Hospital has collectively formulated the "Clinical Practice Guidelines for Ulnar Impaction Syndrome (2024)" (hereinafter referred to as the "Guidelines"). The development process adhered to the guidelines outlined in the World Health Organization's handbook for guideline development.

Results Ten key questions and 21 recommendations are formed. The Guidelines provide recommendations for UIS diagnosis, criteria for selecting conservative or surgical interventions, options for surgical procedures, and address various related issues.

Keywords
- ► ulnar impaction syndrome
- ► diagnosis
- ► treatment
- ► guidelines

received
February 24, 2024
accepted
April 29, 2024
article published online
May 27, 2024

Thieme Medical Publishers, Inc., 333 Seventh Avenue, 18th Floor, New York, NY 10001, USA

DOI https://doi.org/10.1055/s-0044-1787156.
ISSN 2163-3916.

Conclusions The collaborative effort aims to standardize clinical practices, enhance diagnostic accuracy, and improve treatment outcomes for individuals affected by UIS, with these recommendations intended to serve as a valuable reference for healthcare professionals.

Ulnar impaction syndrome (UIS) was first conceptualized by Milch in 1941,[1] describing the prolonged impact of the ulna against the carpal bones during wrist movement, leading to ulnar-sided wrist pain.[2] If left untreated, UIS can result in thinning, perforation of the triangular fibrocartilage complex (TFCC), lunate bone edema, chondromalacia, cystic changes, and even necrosis.[3] Ultimately, UIS can reduce wrist mobility and grip strength and is often overlooked or misdiagnosed as TFCC injury, leading to delayed and inappropriate treatment. Accurate diagnosis and timely intervention are crucial. Thus, evidence-based clinical guidelines for UIS have been collaboratively developed by experts from Huashan Hospital's Hand Surgery Department and the Asian Pacific Wrist Association. The Guidelines aim to provide a scientific approach for diagnosing and treating UIS effectively.

Guidelines Development Process

Guideline Development Principles

The Guidelines were developed in accordance with the "World Health Organization Handbook for Guideline Development"[4] and the "Appraisal of Guidelines for Guidelines for Research and Evaluation."[5] The guideline report refers to the "Reporting Items for Practice Guidelines in Healthcare."[6]

Guideline Working Group

The guideline working group comprised clinical experts in hand surgery, microsurgery, orthopaedics, and methodological experts, along with public representatives.

The group, led by two cochairs (one clinical and one methodological), established five subcommittees: steering group, secretariat, evidence evaluation team, consensus team, and external review team.

Steering Group

The steering group comprised clinical and methodological professors responsible for forming subcommittees, managing conflicts of interest, defining the guideline scope, proposing, and finalizing key questions based on voting, summarizing recommendations from evidence evaluation, overseeing the guideline development process, and approving the final guideline.

Secretariat

Secretariat comprised clinical experts responsible for coordinating intersubcommittee work, drafting the guideline plan, researching clinical issues, organizing consensus meetings, recording the guideline development process, and submitting the guideline for publication.

Evidence Evaluation Group

The evidence evaluation group comprised experts in evidence-based medicine, responsible for structuring clinical questions using the population, intervention, control, and outcomes principle, searching, evaluating, and grading evidence, and creating evidence summaries and recommendation tables.

Consensus Group

The consensus group comprised multidisciplinary experts, including clinical experts in hand surgery, microsurgery, orthopaedics, and methodological experts, representing diverse countries including Australia, China, India, Japan, Korea, Singapore, and other Asia-Pacific countries; they voted on key questions and recommendations.

External Review Group

The external review group comprised clinical professors, methodological professors, and patients with UIS. Their responsibilities included peer-reviewing the final draft of the Guidelines and providing input on significant risks or issues within the Guideline scope and recommendations.

Considering the end-users, two patients were included in the Guideline development, and their input was sought during the external review phase of the final draft.

Evidence Retrieval

The literature search for the Guideline development involved comprehensive searches across databases such as PubMed, Ovid, Web of Science, Embase, and CNKI. Various types of articles, including clinical trials, meta-analyses, randomized controlled trials, reviews, and systematic reviews were considered.

Key search terms included "ulnar impaction syndrome, " "ulnar positive variance, " "ulnar wrist pain," "triangular fibrocartilage complex," "conservative treatment," "surgical treatment," "ulnar shortening osteotomy," "cut," "transverse," "oblique," "freehand," "osteotomy guide," "jig," "locking plate," "nonlocking plate," and "biomechanical," "wafer procedure," "wrist arthroscopy," "distal metaphyseal ulnar shortening osteotomy," "distal radioulnar joint arthritis," "Sauvé–Kapandji," "Darrach," "postoperative," "wrist joint fixation," "rehabilitation," and others.

During the literature retrieval process, articles with content repetition, inconsistent information, and inaccessible full text were excluded to ensure the quality and relevance of the selected literature for online development.

Formation of Key Questions and Recommendations

Formation of Key Questions

A modified Delphi survey method was employed to generate key questions proposed by the steering group and conducted in two rounds. In the first round, questions with a support rate of $\geq$75% were directly accepted. Questions with a support rate of $<$75% but $\geq$50% were modified based on feedback and subjected to a second round of voting. Questions with a support rate of <50% in the first round were eliminated. In the second round, only questions with a support rate of ≥75% were included as key questions.

Formation of Recommendations

Similarly, a modified Delphi survey method was used for two rounds to evaluate the recommendations summarized by the steering group and evidence evaluation team. In the first round, recommendations with a support rate of ≥75% were directly accepted. Recommendations with a support rate of <75% but ≥50% underwent modification based on feedback and a second round of voting. Recommendations with a support rate of <50% in the first round were eliminated. In the second round, only recommendations with a support rate of ≥75% were included as key recommendations.

Evidence Level and Recommendations

Clinical evidence was assessed using the Oxford Centre for Evidence-Based Medicine: Levels of Evidence (March 2009).[7] The evidence was categorized into five levels: 1, 2, 3, 4, and 5. Systematic reviews of randomized controlled trials (RCTs) were assigned the highest level of evidence, denoted as "Level 1." Expert opinion without an explicit critical appraisal, or based on physiology, bench research, or "first principles," was denoted as "Level 5." Different levels of evidence corresponded to different grades of recommendation, as shown in ►**Table 1**.

Summary of Key Questions and Recommendations

The summary of key questions and recommendations is displayed in ►**Table 2**.

Background

The TFCC serves as a crucial mechanical stabilizing structure on the ulnar side of the wrist. Comprising fibrocartilaginous disk, dorsal and palmar radioulnar ligaments, ulnolunate ligament, and homologous structures, the TFCC plays a primary role in stabilizing both the distal radioulnar joint (DRUJ) and the ulnocarpal joint.[8,9]

During daily activities, the carpus load is shared by the radius, ulnar, and TFCC. Approximately 80% of the carpus load is borne by the radius, while the ulnar and TFCC handle the remaining 20% of the neutral ulnar variance.[10] Ulnar-positive variance occurs when the ulna is longer than the radius, with the ulnocarpal side experiencing stress proportional to the degree of positive variance. When ulnar-positive variance exceeds 2.5 mm, stress on the ulnar side can increase from 20 to 40%.[11]

Direct impaction and increased pressure on the ulnar side, resulting from ulnar positive variance, accelerate TFCC wear and degeneration. This can lead to thinning and even perforation of the central portion.[12] Repetitive impact of the ulnar head on the lunate or triquetrum can cause pathological changes such as chondromalacia, peeling, bone marrow edema, liquefied cystic changes, and, in severe cases, necrosis.

It is noteworthy that wrist ulnar pressure also increases during activities such as pronation, fist clenching, and ulnar deviation.[13] A retrospective case study revealed an average ulnar-positive variance of 2 mm during pronation,[14] providing insights into the pathogenesis of UIS in cases without ulnar variance in static anteroposterior X-ray view.

Question 1: How is Ulnar Impaction Syndrome Diagnosed?

Recommendation 1.1: Diagnosing UIS involves a comprehensive assessment comprising medical history, physical examination, and relevant imaging results. UIS should not be considered in the absence of supportive X-ray and magnetic resonance imaging (MRI) findings (Evidence Level 4, Recommendation Grade C).

Recommendation 1.2: X-ray and MRI are recommended as the primary imaging modalities for diagnosing UIS (Evidence Level 4, Recommendation Grade C).

Table 1 Oxford Centre for Evidence-Based Medicine: levels of evidence (March 2009)

Grades of recommendation	Level of evidence	Content
A	1a	A systematic review (with homogeneity) of RCTs
	1b	Individual RCT (with narrow confidence interval)
	1c	All of none (met when all patients died before the Rx became available, but some now survive on it; or when some patients died before the Rx became available, but none now die on it)
B	2a	A systematic review (with homogeneity) of cohort studies
	2b	Individual cohort studies (including low-quality RCT, e.g., <80% follow-up)
	3a	A systematic review (with homogeneity) of case-control studies
	3b	Individual case-control studies
C	4	Case series (and poor-quality cohort and case-control studies)
D	5	Expert opinion without an explicit critical appraisal, or based on physiology, bench research or "first principles"

Abbreviation: RCT, randomized controlled trials.

Table 2 Summary of key questions and recommendations

Key questions	Recommendations
1. How is UIS diagnosed?	1.1. Diagnosing UIS involves a comprehensive assessment comprising medical history, physical examination, and relevant imaging results. UIS should not be considered in the absence of supportive X-ray and MRI findings (Evidence Level 4, Recommendation Grade C).
	1.2. X-ray and MRI are recommended as the primary imaging modalities for diagnosing UIS (Evidence Level 4, Recommendation Grade C).
2. Is conservative treatment effective for UIS?	2.1. Conservative treatment is recommended as the primary therapeutic approach for UIS (Evidence Level 4, Recommendation Grade C).
3. What are the early surgical indications for patients with UIS?	3.1. Early surgical intervention is strongly recommended for patients with UIS experiencing ulnar-sided wrist pain persisting for 6 months or exhibiting severe clinical symptoms (Evidence Level 4, Recommendation Grade C).
	3.2. Early surgical intervention is recommended for UIS patients with concurrent DRUJ instability (Evidence Level 4, Recommendation Grade C).
4. What are the considerations when applying USO?	4.1. USO is a precise and recommended standard treatment for UIS (Evidence Level 2b, Recommendation Grade B).
	4.2. Caution is advised when applying USO in cases of DRUJ in reverse oblique sigmoid (Evidence Level 4, Recommendation Grade C).
	4.3. It is recommended to place internal fixation plates on the volar side of the ulna (Evidence Level 2b, Recommendation Grade B).
5. What kind of plate is recommended to fix the osteotomy during USO surgery?	5.1. Both locking and nonlocking plates are recommended as internal fixation in USO surgery. (Evidence Level 4, Recommendation Grade C).
6. What is the safe osteotomy length for the wafer/AWP?	6.1. It is recommended to apply wafer/AWP for UIS with the ulnar-positive variance of <2 mm (Evidence Level 2b, Recommendation Grade B).
	6.2. When the anticipated osteotomy length exceeds 3 mm, the use of wafer/AWP is not recommended (Evidence Level 5, Recommendation Grade D).
7. When should DMUSO be considered?	7.1. Applying DMUSO for anticipated osteotomy lengths of <5 mm in UIS is recommended (Evidence Level 4, Recommendation Grade C).
	7.2. The choice of internal fixation can be determined by the osteotomy method. Preferably, buried head compression screws are recommended as they lead to fewer postoperative complications (Evidence Level 4, Recommendation Grade C).
8. What is the role of TFCC repair in treating UIS?	8.1. It is not recommended to solely use TFCC repair for treating UIS (Evidence Level 4, Recommendation Grade C).
	8.2. For cases where DRUJ remains unstable after ulnar shortening, it is recommended to consider concomitant TFCC foveal repair to restore DRUJ stability (Evidence Level 4, Recommendation Grade C).
9. How to treat patients with UIS with severe DRUJ arthritis?	9.1. S–K and Darrach surgeries are both recommended as salvage procedures (Evidence Level 2a, Recommendation Grade B).
	9.2. S–K surgery is more suitable for young and male patients with higher wrist joint function requirements (Evidence Level 4, Recommendation Grade C).
	9.3. Darrach surgery is more suitable for elderly patients with lower joint function requirements (Evidence Level 4, Recommendation Grade C).
10. How about the postoperative immobilization and rehabilitation strategies for UIS?	10.1. A short-arm orthosis is suggested to be enough for immobilization for 4 weeks after USO, with rehabilitation exercises commencing after the 4th week (Evidence Level 2b, Recommendation Grade B).
	10.2. A 2-week immobilization with a short-arm splint is recommended after a wafer procedure. Initiating exercises that involve making a fist or engaging in axial stress training of the wrist is not advised within the first 2 weeks postoperatively (Evidence Level 2b, Recommendation Grade B).
	10.3. For DMUSO, short-arm plaster fixation for 7–10 days, followed by a switch to a wrist brace, with rehabilitation starting on the 10th postoperative day (Evidence Level 4, Recommendation Grade C).

Abbreviations: AWP, arthroscopic wafer procedure; DMUSO, distal metaphyseal ulnar shortening osteotomy; DRUJ, distal radioulnar joint; MRI, magnetic resonance imaging; S–K, Sauvé–Kapandji; TFCC, triangular fibrocartilage complex; UIS, ulnar impaction syndrome; USO, ulnar shortening osteotomy.

Medical History and Physical Examinations

The onset of UIS is typically gradual, with patients complaining of prolonged wrist ulnar-sided pain after maintaining a specific position. Trauma can also lead to wrist ulnar-sided pain, prompting medical attention. The ulnocarpal stress test is a sensitive physical examination. During the examination, the wrist is positioned in full ulnar deviation. Axial pressure is applied to the wrist joint, while the forearm is passively rotated through pronation to supination. The examination for UIS typically yields a positive result in patients with this condition.[15] However, a positive result may also be indicative of other issues such as a TFCC injury (without UIS), scapholunate ligament damage, or isolated arthritis.[16] Patients with concurrent TFCC injury may also present positive fovea signs or increased ulnar-sided pain during rotation. Patients with unstable DRUJ may exhibit tenderness on the dorsal aspect of the ulnar head and a positive DRUJ ballottement test.[17] Positive findings in the lunotriquetral ballottement test may indicate instability in the midcarpal joint. However, given the numerous conditions causing ulnar-sided wrist pain (approximately 20),[1,18] a diagnosis based solely on medical history and physical examination is insufficient.

Imaging Examination

Imaging studies should include wrist MRI[17] and wrist X-rays.[19] Wrist MRI results take precedence, followed by static anteroposterior X-ray views or prone X-ray views of the wrist. MRI findings should include (1) increased signal intensity in the lunate, triquetrum, or ulnar head in T2-weighted coronal MRI[20] (►**Fig. 1A**) and (2) thinning or perforation of the central portion of the TFCC in T2-weighted images[21] (►**Fig. 1A**). Wrist X-rays typically reveal ulnar positive variance[22] (►**Fig. 1B**). Patients without apparent ulnar-positive variance on wrist X-rays should undergo forearm rotation views to confirm dynamic ulnar impaction. Severe cases with cystic changes on the ulnar side of the lunate or triquetrum may exhibit circular low-density shadows on X-rays[20] (►**Fig. 1B**).

Question 2: Is Conservative Treatment Effective for Ulnar Impaction Syndrome?

Recommendation 2.1: Conservative treatment is recommended as the primary therapeutic approach for UIS (Evidence Level 4, Recommendation Grade C).

Conservative treatment has proven effective for UIS,[23,24] especially during the initial diagnosis, where it should be the preferred option.[2] The treatment plan should include splint immobilization and symptomatic pain relief through medication. The conservative treatment regimen typically involves continuous splint fixation for 4 weeks and intermittent wear for 2 weeks, followed by 6 weeks of rehabilitation after the splint removal.[23]

For patients experiencing significant ulnar-sided wrist pain, oral nonsteroidal anti-inflammatory drugs (NSAIDs) can be administered for symptomatic relief. In cases of severe ulnar-sided pain, especially when NSAIDs are not sufficiently effective, localized pain point blockade on the ulnar side of the wrist may be considered.[25]

Additionally, activities that exacerbate the ulnar load, such as ulnar deviation and forceful pronation of the wrist, should be minimized.[16]

Long-term splint immobilization has improved pain scores (visual analog scale [VAS]) with an overall improvement rate of 51.7%.[24] After 6 weeks of splint fixation and an additional 6 weeks of rehabilitation, 59% of patients achieved a numeric rating scale score of <5, indicating successful conservative treatment.[23] Conversely, 41% of patients with a score of ≥ 5 were considered conservative treatment failures. For patients who do not respond positively to conservative treatment, surgical intervention should be considered.

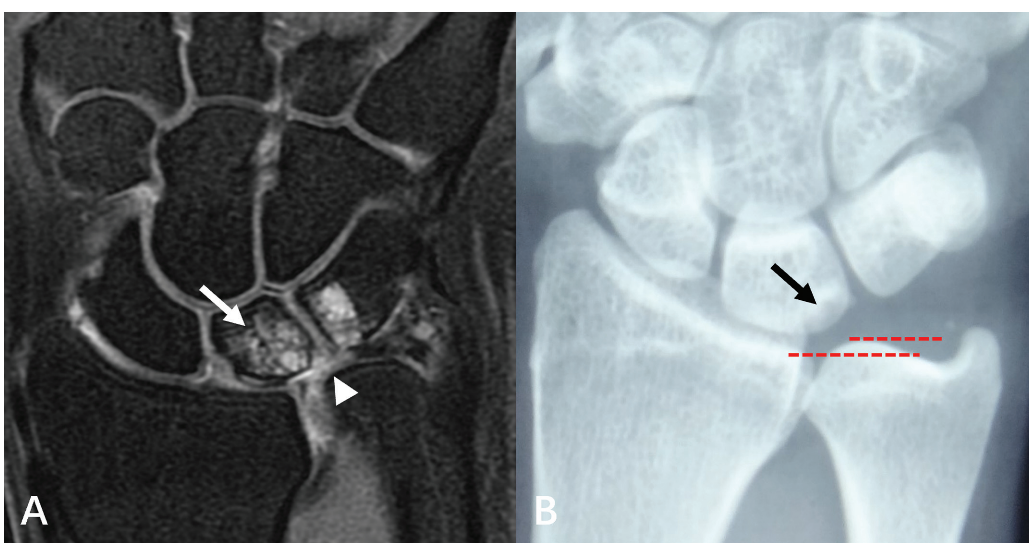

Fig. 1 (**A**) T2-weighted coronal MRI demonstrates increased signal intensity in the lunate (*indicated by an arrow*) and thinning and perforation of the central portion of the TFCC (*marked by a triangle*). (**B**) Ulnar positive variance (*demarcated by red lines*) and a low-density shadow in the lunate (*indicated by an arrow*) are observed in the anteroposterior view of the X-ray.

Question 3: What are the Early Surgical Indications for Patients with Ulnar Impaction Syndrome?

Recommendation 3.1: Early surgical intervention is strongly recommended for patients with UIS experiencing ulnar-sided wrist pain persisting for 6 months or exhibiting severe clinical symptoms (Evidence Level 4, Recommendation Grade C).

Recommendation 3.2: Early surgical intervention is recommended for UIS patients with concurrent DRUJ instability (Evidence Level 4, Recommendation Grade C).

Conservative treatment for patients with UIS often spans a lengthy period, typically extending beyond 6 weeks, with a success rate usually <60%.[23,24] Identifying high-risk patients and reducing the time cost of awaiting surgery are crucial for an early return to daily life.

Case series studies indicate that conservative treatment is often less effective when wrist joint pain persists without improvement or when wrist joint range of motion and grip strength are remarkably decreased. A case series followed 16 patients who underwent ulnar shortening osteotomy (USO) due to UIS. All patients presented with prolonged ulnar-sided wrist pain accompanied by reduced wrist joint range of motion and weakened grip strength. Even after 6 months of conservative treatment (wrist joint bracing and anti-inflammatory medications) with little improvement, all patients achieved favorable outcomes following USO. Postoperatively, VAS scores, forearm rotation angles, and grip strength significantly improved, without reported complications.[26] Another large-sample case series study also yielded similar findings.[25]

Early surgical intervention is recommended for UIS patients with concurrent DRUJ instability.[27] In a case series study, surgery was confirmed as a reliable method to improve UIS with DRUJ instability. Postoperatively, patients reported an average VAS score, Quick Disabilities of the Arm, Shoulder, and Hand (Quick-DASH) score; and Patient-Rated Wrist Evaluation score of 0.7/10 (range, 0–4), 16.9 (range, 0–48), and 21.9 (range, 16.9–59)—all indicating significant improvements compared with preoperative values. In this study, 96% of patients perceived themselves as improved through surgery, with no patients reporting worsened conditions.

Question 4: What are the Considerations When Applying Ulnar Shortening Osteotomy?

Recommendation 4.1: USO is a precise and recommended standard treatment for UIS (Evidence Level 2b, Recommendation Grade B).

Recommendation 4.2: Caution is advised when applying USO in cases of DRUJ in reverse oblique sigmoid (Evidence Level 4, Recommendation Grade C).

Recommendation 4.3: It is recommended to place internal fixation plates on the volar side of the ulna (Evidence Level 2b, Recommendation Grade B).

USO is one of the most common procedures for treating UIS.[12] This procedure involves removing a specific length of the ulna to eliminate positive variance, reduce repetitive grinding impact between the ulna and lunate, alleviate excessive loading on the ulnocarpal joint, and enhance DRUJ stability.[28,29]

USO involves osteotomy at the distal 1/3 of the ulnar shaft. The advantages of this extra-articular surgery include not requiring the joint capsule to be opened, avoiding DRUJ cartilage and joint surface damage, and preserving the intact TFCC structure.[30] A case report ($n = 32$) demonstrated that for patients diagnosed with UIS treated with USO, wrist joint flexion-extension increased from an average of 82.7 to 101.2 degrees and ulnar-radial deviation and pronation-supination significantly improved. The wrist joint VAS score decreased from an average of 7.7 to 1.7.[12] Additionally, USO shortens the ulna and increases tension in the joint capsule and surrounding ligaments, thereby enhancing DRUJ stability.[25,27,31]

The DRUJ sigmoid notch should be considered before applying USO. A case series of 100 cases and a biomechanical study indicated that the ulnar head may collide with the distal radial sigmoid notch after USO in Tolat C-type DRUJ (reverse oblique sigmoid),[16,32] increasing contact pressure and leading to DRUJ arthritis. Therefore, caution is advised when using USO for DRUJ with reverse oblique sigmoid.[33]

The influence of the osteotomy type (transverse or oblique) and the osteotomy technique (freehand or osteotomy guide) on the union rate has been a focal point of debate in USO procedures. Oblique osteotomy provides a larger contact surface at the osteotomy ends, which is advantageous for healing. Screws can be inserted perpendicular to the osteotomy surface to enhance compression at the osteotomy ends. Osteotomy guides theoretically offer more precise control over the osteotomy length.

However, a meta-analysis involving 37 studies and 1,423 patients showed that in USO procedures, the nonunion rates were 4.16% for transverse osteotomy and 3.86% for oblique osteotomy, with no significant differences between the two types. The nonunion rate for freehand oblique osteotomies was 5.06%, compared with 2.9% for oblique osteotomies performed with an osteotomy guide. Although the nonunion rate was slightly higher for freehand procedures, the difference was not statistically significant.[34] Therefore, surgeons can choose the osteotomy type and technique based on the patient's specific condition and personal preference rather than the union rate.

Furthermore, placing the plate on the dorsal side of the ulna more likely results in postoperative irritation.[35] Multiple retrospective cohort studies suggest a postoperative plate removal rate of 45 to 65% for dorsal plates,[36,37] significantly lower at 25% for palmar plates.[38]

Question 5: What kind of Plate is Recommended to Fix the Osteotomy during Ulnar Shortening Osteotomy Surgery?

Recommendation 5.1: Both locking and nonlocking plates are recommended as internal fixation in USO surgery (Evidence Level 4, Recommendation Grade C).

Nonlocking and locking plates are the choice of internal fixation. Retrospective analyses have indicated that the nonunion rates for nonlocking plates in USO procedures range from 0 to 17.9%, with an average bone healing duration of 8.1 to 41.8 weeks.[39–45] Locking plates have shown a nonunion rate of 0 to 14.3%, with an average bone healing duration of 7 to 11 weeks.[46–49] Although the nonunion rate and the bone healing duration seem to be extended with nonlocking plates, drawing statistical conclusions remains difficult. Furthermore, due to many inconsistencies in definitions of both nonunion and delayed union across various studies, higher-level clinical research is required to unify these definitions and assist surgeons in determining the optimal plate type for the USO procedure. Moreover, biomechanical research about USO has not demonstrated a significant biomechanical advantage for locking plates over nonlocking plates. The final destructive tests revealed that axial rotational loading in which the locked plate is constructed failed earlier than the nonlocked plates.[50] Therefore, based on the current evidence, both types of plates can be used in USO surgery without a preference for one over the other.

Question 6: What is the Safe Osteotomy Length for the Wafer/Arthroscopic Wafer Procedure?

Recommendation 6.1: It is recommended to apply wafer/arthroscopic wafer procedure (AWP) for UIS with the ulnar-positive variance of <2 mm (Evidence Level 2b, Recommendation Grade B).

Recommendation 6.2: When the anticipated osteotomy length exceeds 3 mm, the use of wafer/AWP is not recommended (Evidence Level 5, Recommendation Grade D).

The wafer procedure was first proposed in 1992[51] and involves the resection of 2 to 4 mm from the distal end of the ulnar head to achieve ulnar carpal decompression.[52] With the advancement of arthroscopic techniques, the open wafer procedure can now be completed arthroscopically, known as the AWP.[53] Intraoperatively, the 3 to 4 portal is used as the observation portal, and a burr is placed through the 6R portal, taking advantage of the central perforation of the TFCC to perform limited resection of the ulnar head. Research indicates that AWP and open wafer surgery have comparable clinical effectiveness but consensus is lacking on whether AWP offers a shorter recovery period and lower postoperative complication rates.[12,54] The choice between open wafer and AWP often depends on the surgeon's expertise.

The safe osteotomy distance for the wafer has not been clearly defined. Multicenter RCTs with high evidence grades showed that AWP in UIS patients with an average ulnar-positive variance of ≤2.2 mm achieved satisfactory clinical outcomes comparable to the USO group. The AWP group had no complications like DRUJ instability or arthritis during follow-up.[55] Another retrospective cohort study demonstrated that AWP is effective for UIS with an average ulnar-positive variance of 3 mm. Grip strength improvement was better than the USO group, and the postoperative complication rate was significantly lower than the USO group.[56]

However, a cadaver study indicates that increased ulnar-side pressure is significantly positively correlated with the length of ulnar head grinding. When the ulnar head is ground down by 1, 2, and 3 mm, ulnar-side pressure increases by 29, 57, and 86%, respectively. Once the length of ulnar head removal reaches 4 mm, ulnar-side pressure doubles,[57] and excessive ulnar-side load is a major cause of arthritis.[28] Therefore, considering the limited evidence, a 2 mm osteotomy length is considered safe, but caution is advised when anticipating a 3 mm osteotomy length. When the expected osteotomy length reaches or exceeds 4 mm, the wafer/AWP should not be used.

Since wafer/AWP prevents issues such as osteotomy, nonunion, internal fixation irritation, and internal fixation removal, it has lower potential complications and reoperation rates.[30] Thus, within the safe osteotomy range, wafer surgery can be considered an alternative to USO.[37] This is particularly advantageous for UIS patients with Tolat C-type DRUJ reverse oblique sigmoid.[55]

Question 7: When Should Distal Metaphyseal Ulnar Shortening Osteotomy Be Considered?

Recommendation 7.1: Applying DMUSO for anticipated osteotomy lengths of <5 mm in UIS is recommended (Evidence Level 4, Recommendation Grade C).

Recommendation 7.2: The choice of internal fixation can be determined by the osteotomy method. Preferably, buried head compression screws are recommended as they lead to fewer postoperative complications (Evidence Level 4, Recommendation Grade C).

The DMUSO technique was first detailed by Slade in 2007,[58] although there is still no consensus on its indications and contraindications.[59] A case series study involving 43 patients found that DMUSO,[60] with over 6 months of follow-up, demonstrated satisfactory clinical outcomes for ulnar-positive variance within 5 mm. It significantly improved grip strength and dorsal extension angle of the wrist. However, evidence for ulnar-positive variance at or ≥5 mm is currently lacking, even though a cadaveric study suggests that DMUSO may have a similar or longer osteotomy distance compared with USO.[61] Researchers observed that DMUSO was more effective than USO in relieving pain and Quick-DASH scores were higher.[62] Additionally, due to the distal location of the osteotomy in DMUSO, it reduced the separation and traction effects of the interosseous membrane on the osteotomy ends. With a rich blood supply in the distal metaphysis, DMUSO required a shorter healing time and had a lower nonunion rate compared with USO.[59] Currently, no reported evidence has regarded contraindications for DMUSO based on a search of multiple databases.

For DMUSO fixation, either buried head compression screws (wedge osteotomy) or ulnar distal plates (transverse osteotomy) can be chosen based on the osteotomy's morphology. Both fixation methods can achieve good bone healing results. A case report using ulnar distal plate fixation revealed that, despite 4% of patients experiencing delayed healing due to early postoperative activity, satisfactory healing results were eventually achieved. About 32% of patients experienced internal fixation irritation postoperatively, resulting in a secondary internal fixation removal surgery approximately 7 months later but the subsequent modification of the plate significantly reduced the incidence of postoperative internal fixation irritation.[28] Conversely, buried head compression screws had rare reports of postoperative internal fixation irritation and secondary surgery for removal. The fixation method is flexible, allowing either retrograde fixation from the ulnar head cartilage surface to the distal end or antegrade fixation from the ulnar shaft to the ulnar head. The number of screws can be a single or double fixation.[58,59,63] A cadaver study indicated that two antegrade screws provided the highest resistance to rotation stability while avoiding damage to the joint surface caused by internal fixation.[63,64]

Question 8: What is the Role of Triangular Fibrocartilage Complex Repair in Treating Ulnar Impaction Syndrome?

Recommendation 8.1: It is not recommended to solely use TFCC repair for treating UIS (Evidence Level 4, Recommendation Grade C).

Recommendation 8.2: For cases where DRUJ remains unstable after ulnar shortening, it is recommended to consider concomitant TFCC foveal repair to restore DRUJ stability (Evidence Level 4, Recommendation Grade C).

Patients with UIS frequently have concomitant TFCC injuries. Current clinical studies confirm that performing only TFCC debridement and repair does not effectively alleviate ulnar-sided wrist pain in patients with confirmed UIS. A case series involving 163 patients found that approximately 25 to 30% of patients with UIS who underwent only TFCC debridement and repair needed subsequent USO treatment within 3.6 months postoperatively.[65] A retrospective cohort study involving 72 cases reported that repairing TFCC alone could provide short-term ulnar-positive variance improvement. However, over time (average follow-up of 26.8 weeks), ulnar-positive variance tended to worsen again,[66] accompanied by ulnar-sided wrist pain. In contrast, ulnar shortening surgery effectively improved clinical symptoms in patients with UIS. An analysis revealed that for patients with UIS with TFCC central perforation or radial edge tears that cannot be sutured and repaired, performing only USO achieved clinical results comparable to USO combined with TFCC debridement. No significant differences in postoperative hand function scores, grip strength, and pain relief were observed between the two groups.[67] Even in patients with UIS with minor TFCC injuries and DRUJ instability, most of them achieved significant improvement in DRUJ stability through USO.[68] The mechanism has been elucidated quite clearly.[29,69] For patients with persistent DRUJ instability after shortening, a combined procedure is needed to repair the TFCC foveal to restore DRUJ stability.[28,68]

Specialists must note that some patients present with ulnar-sided wrist pain, DRUJ instability, and ulnar-positive variance in clinical practice. Moreover, primary UIS should be differentiated from secondary ulnar-positive variance due to DRUJ instability. The treatment approaches for these conditions differ. Primary UIS requires high signal intensity, thinning, or even central perforation of the TFCC that can usually be identified on MRI. If ulnar-positive variance is caused by DRUJ instability, patients typically have a clear history of trauma. MRI commonly shows no obvious signal changes in the ulnar-positive variance, and TFCC injuries are more concentrated in the ulnar-sided fovea, rather than central perforations. A case series study involving 140 patients reported that TFCC deep support injuries could increase ulnar-positive variance by 0.56 mm. After restoring DRUJ stability through repair, the ulnar-positive variance was reduced from 0.56 to 0 mm.[70] Therefore, detailed history taking, thorough physical examination, and careful image interpretation are essential.

Question 9: How to Treat Patients with Ulnar Impaction Syndrome with Severe Distal Radioulnar Joint Arthritis?

Recommendation 9.1: Sauvé–Kapandji (S–K) and Darrach surgeries are both recommended as salvage procedures (Evidence Level 2a, Recommendation Grade B).

Recommendation 9.2: S–K surgery is more suitable for young and male patients with higher wrist joint function requirements (Evidence Level 4, Recommendation Grade C).

Recommendation 9.3: Darrach surgery is more suitable for elderly patients with lower joint function requirements (Evidence Level 4, Recommendation Grade C).

Darrach and S–K surgeries are currently the two most widely used salvage procedures for wrist joint function restoration.[71] In patients with severe DRUJ arthritis, limited forearm rotation in UIS, where USO and wafer procedures fail to alleviate symptoms such as pain, grip strength, and reduced joint mobility, Darrach surgery involving the removal of the entire ulnar head[72] or S–K surgery, which includes partial osteotomy of distal ulnar and DRUJ fusion,[73] becomes necessary to improve forearm rotation function and wrist pain.

Darrach surgery involves the complete removal of the ulnar head to alleviate wrist pain caused by arthritis. However, due to the loss of ulnar head support, complications such as volar or dorsal instability of the radiocarpal joint, ulnar deviation of the wrist joint, and impingement between the residual ulna and the radial aspect may occur.[74]

With a deeper understanding of TFCC, researchers have realized the importance of preserving TFCC for maintaining DRUJ stability. S–K surgery, by retaining the ulnar head and TFCC along with surrounding ligamentous structures, provides better rotational and axial stability compared with Darrach.[74] However, due to DRUJ fusion, postoperative complications such as delayed healing, nonunion, or pseudoarthrosis increase, resulting in a higher overall complication rate compared with Darrach. Additionally, when ulnar shortening exceeds 5 mm, it may induce painful instability of the ulnar stump.[75] Currently, the management of painful instability of the ulnar stump involves ulnar head replacement[76] or DRUJ replacement.[77]

A retrospective analysis involving 1,267 patients demonstrated that surgeons were more inclined to perform S–K surgery on younger and male patients.[78] Patients undergoing S–K surgery were 5 to 18 years younger than those undergoing Darrach surgery.[79–82] This preference might be attributed to the fact that S–K surgery preserves ulnar structures, maintaining ulnar stress transmission and considering grip strength improvements. Conversely, Darrach surgery is more common in females aged over 56 years, aiming to avoid several complications associated with S–K surgery. A systematic review of 47 studies found that both S–K and Darrach surgeries significantly improved forearm rotational mobility; however, the return-to-work rate was notably higher for S–K surgery (86 vs. 63%).[71]

Question 10: How about the Postoperative Immobilization and Rehabilitation Strategies for Ulnar Impaction Syndrome?

Recommendation 10.1: A short-arm orthosis is suggested to be enough for immobilization for 4 weeks after USO, with rehabilitation exercises commencing after the 4th week (Evidence Level 2b, Recommendation Grade B).

Recommendation 10.2: A 2-week immobilization with a short-arm splint is recommended after a wafer procedure. Initiating exercises that involve making a fist or engaging in axial stress training of the wrist is not advised within the first 2 weeks postoperatively (Evidence Level 2b, Recommendation Grade B).

Recommendation 10.3: For DMUSO, short-arm plaster fixation for 7 to 10 days, followed by a switch to a wrist brace, with rehabilitation starting on the 10th postoperative day (Evidence Level 4, Recommendation Grade C).

Patients undergoing different surgeries for UIS have varying durations of joint immobilization and different timings for rehabilitation. USO is the most commonly used procedure; however, its severe complication, nonunion, occurs at a rate of 4 to 18%.[25,34,83] Nonunion of fractures is a complex outcome influenced by multiple factors. It is difficult to make immediate predictions during or right after surgery. There is also no consensus on whether early plaster, brace, or orthosis fixation postoperatively can truly reduce the incidence of fracture nonunion after USO. A case series involving 106 patients indicates that early long-arm plaster fixation can effectively reduce rotational stress on the fracture ends, promoting fracture healing.[84] This involves wearing a long-arm plaster for the first 2 weeks and a long-arm thermoplastic orthosis for the next 2 to 4 weeks, with wrist flexion/extension exercises starting from the 2nd week and forearm rotation exercises starting after the 6th week. Refixation was performed in six patients (6%) because of nonunion. They also reported that six patients were not smokers. The reason for nonunion was not clearly clarified in the "Discussion" section. Another multicenter RCT demonstrates that short-arm plaster is sufficient for post-USO fixation.[55] In this study, a short, below-elbow orthosis was used for 2 weeks and switched to another thermoplastic orthosis for 2 weeks, with digital exercises immediately after the surgery and wrist joint rehabilitation training starting from the 4th week. Ultimately, all patients showed significant improvements in wrist joint mobility and joint function scores, without nonunion or joint stiffness.[55] Some reports also advocate early functional exercises, with incomplete short plaster fixation for 12 days and the initiation of rehabilitation exercises after plaster removal, showing no cases of nonunion.[85] However, an issue of nonunion has also been reported with too early activity. A retrospective cohort study involving 40 patients reported that immediate wrist movement after the USO resulted in a 10% rate of nonunion.[86] Based solely on the current evidence available, a definitive recommendation regarding early immobilization after the USO surgery cannot be established. Therefore, for early fixation following USO, we have used the term "suggest." Regardless of the chosen fixation method, early active movement is advocated for all nonfixed joints postoperatively. This not only avoids impacting bone healing[85] but also promotes reduced swelling.[48]

Notable differences were observed in postoperative immobilization strategies across various studies referring to wafer procedures. A retrospective case report involving 12 patients indicated that initiating immediate postoperative wrist rotational and flexion-extension rehabilitation exercises resulted in a 58% rate of pain relief.[86] Conversely, a retrospective cohort study involving 33 patients found that immobilizing the wrist with a volar splint for 10 days postwafer surgery yielded an average VAS score of <1.[30] Thus, although the wafer procedure does not require a union process, a short-term postoperative cast is deemed necessary. Another retrospective case report of 12 patients who began rotational exercises and forceful gripping after the 1st week of postwafer surgery showed a 67% improvement rate in the VAS score.[87] Another retrospective analysis involving 26 patients reported that adopting a 2-week immobilization period followed by the commencement of rehabilitation exercises starting in the 3rd week postoperatively resulted in an 84.6% improvement rate in the VAS score.[88] Therefore, rehabilitation exercises involving forceful gripping within the 1st week postoperatively may potentially result in negative effects on pain improvement.

An RCT with a sample size of 60 utilized a 4-week postoperative short-arm cast immobilization strategy followed by rehabilitation exercises. The postoperative wafer group saw a reduction in VAS scores from an average of 6.5 preoperatively to 0.7 postoperatively, with grip strength on the affected side improving from 66 to 87% compared with the unaffected side.[55] Another retrospective cohort study implemented a postoperative strategy that involved a 2-week fixation with a short-arm plaster cast, followed by an additional 4-week immobilization using a thermoplastic splint. Rehabilitation training aimed at restoring joint mobility was encouraged beginning in the 3rd week. It was not until the 7th week that exercises such as making a fist and axial loading were initiated. This approach resulted in an 84.6% improvement rate in pain outcomes.[89] While there are longer immobilization strategies exceeding 6 weeks, the absence of case data precludes comparison.[63]

Due to richer blood supply in the distal metaphysis, the probability of postoperative nonunion was lower in DMUSO than in USO,[90] requiring a shorter fixation time and earlier intervention in wrist joint rehabilitation. A case series ($n = 8$) indicates that after DMUSO, wearing a long-arm plaster for 7 to 10 days, patients can switch to a removable splint for protection and begin hand function rehabilitation training, achieving 85 to 99% of wrist joint flexion, extension, and rotational mobility at 13 months postoperatively compared with the unaffected side. The grip strength increased to 88%

of the healthy side afterward. No nonunion occurred postoperatively.[59] Another case series, with a sample size of 43 patients, reported that patients were immobilized postoperatively using a sugar-tong splint for 3 weeks. Following the removal of the splint, rehabilitation exercises were initiated. A statistically significant improvement in patients' grip strength was observed, which increased on average from 77% of the healthy side preoperatively to 87% of the healthy side afterward. The range of motion in wrist extension also showed statistically significant improvement (from 63.1 degrees preoperatively to 69.1 degrees postoperatively). The successful union was achieved as expected postoperatively in all patients.[60]

Discussion

UIS is a prevalent yet often underdiagnosed condition. This guideline, as the world's first publicly oriented clinical guide, provides a detailed overview of the pathogenesis, key diagnostic criteria, and various treatment modalities for UIS. It aims to assist health care professionals and patients in conducting more scientifically informed clinical activities.

Remarkably, the content covered in this guideline may not be fully comprehensive. With our deepened understanding of the condition and anatomy, advanced surgical techniques, and evolving internal fixation devices, ongoing updates of treatment indications and techniques are required. This guideline will undergo periodic revisions to incorporate these advancements.

Note

The guideline is developed in Shanghai, China.

Authors' Contributions

W.X. initiated the guideline and wrote the manuscript. Y.C. was responsible for the methodology. All authors contributed to the scoping of the guidelines and development of the key questions and recommendations. All authors approved the final manuscript.

Funding

New clinical methods for restoring functions in paralyzed limbs and lost speech, along with the development of new brain–computer interface neuroregulation technologies (2022YFC3602700 and 2022YFC3602701).

Conflict of Interest

None declared.

Acknowledgments

The authors thank Yudong Gu (Academician of the Chinese Academy of Engineering) and two patients with UIS for external review on this consensus. Huawei Yin and Yangchun Wu served as the secretariats. Qianling Shi, Yunuo Chen, Xingyi Ma, and Zirui Yu helped with evidence evaluation. The authors thank all the members of the secretariat and evidence evaluation group for their excellent work.

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