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Ulnar collateral ligament reconstruction in athletes using a cortical button suspension technique

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Background: A variety of techniques currently exist for ulnar collateral ligament (UCL) reconstruction in symptomatic overhead athletes, all with the potential complication of fracture about the humeral or ulnar tunnels. Far cortical button fixation is a reproducible, biomechanically attractive option; however, no clinical series has been published on this technique to date. This study reports the clinical outcomes, with minimum 2-year follow-up, of a dual far cortical button suspension technique for UCL reconstruction in athletes.

Methods: A retrospective evaluation was performed of 23 consecutive athletes who underwent UCL reconstruction with the use of ulnar and humeral-sided far cortical button fixation with minimum 2 years of follow-up. Data were collected from electronic medical records and patient telephone calls. The primary outcome was return to sport. Secondary outcomes included Disabilities of the Arm, Shoulder and Hand score, range of motion, and complications.

Results: We included 23 athletes with a mean follow-up of 47.2 months (range, 24-81 months). Autograft was used in 22 patients (16 palmaris, 6 gracilis, 1 semitendinosus, and 1 gracilis allograft). Overall, 82.6% (19 of 23) of patients returned to sport. At final follow-up, the average Disabilities of the Arm, Shoulder and Hand score was 3.8, and range of motion averaged 0° to 140°, with 87% (20 of 23) of patients achieving full motion. The visual analog scale score improved from 3.8 preoperatively to 0.2 at the final follow-up ($P < .0001$). There was 1 reconstruction failure.

Conclusions: The humeral and ulnar far cortical button suspension technique provides a new UCL fixation option with theoretically lower concern for tunnel fracture and with predictable return to sport and good functional outcomes.

Level of evidence: Level IV; Case Series; Treatment Study

Keywords: Ulnar collateral ligament reconstruction; Tommy John; cortical button suspension; UCL; thrower; elbow instability; docking technique

When nonoperative methods fail, ulnar collateral ligament (UCL) reconstruction has resulted in good return to sport in the competitive, overhead, athlete with dynamic valgus instability secondary to UCL rupture.[4,5,17] A variety of reconstruction techniques currently exist, all with the potential complication of fracture about the humeral or ulnar

The University of Pennsylvania Institutional Review Board approved this study (Protocol #827391).

The inspiration for this technique came from a case report of the first use of this technique.[16]

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tunnels.[5,6,18] Reconstruction of the UCL was originally described by Jobe et al,[10] who named the operation after the first patient, Tommy John.

The original technique involved taking down the flexor-pronator mass and an obligatory submuscular transposition of the ulnar nerve. It was groundbreaking in allowing 62.5% of throwers to return to preinjury level of play but was fraught with a 31.3% complication rate mostly related to ulnar nerve symptoms.[10] The muscle-splitting approach was first described by Smith et al[21] to address this issue. This technique allows the ulnar nerve to be left in situ and is used widely due to a low rate of ulnar nerve complications.[21,22]

Jobe et al[10] originally described a figure-of-8 reconstruction requiring 3 large drill holes in the medial epicondyle. Concern over the risk of fracture led to the advent of the docking technique originally described by Rohrbough et al.[20,24] The excellent clinical results of the docking technique resulted in it becoming the gold standard technique, with a recent large series showing 83% return to same or better level and 93% satisfaction at a minimum of 10-year follow-up.[17] Fracture at the ulnar bone bridge[18] and at the humeral epicondyle[5] remain a concern, however.

Dines et al[6] developed a hybrid technique to address bone deficiency at the sublime tubercle, which may be encountered in revision situations. Using an ulnar interference screw combined with a humeral docking technique, they reported excellent clinical results in 86% (19 of 22) of athletes.[6] Although interference screw fixation is attractive, the biomechanical data calls its strength into question as a primary fixation option. Load to ultimate failure for interference screw and the Jobe techniques are inferior to docking and button suspension techniques.[2]

Cortical button fixation has proven to offer an efficient and reliable option in anterior cruciate ligament reconstruction and biceps tendon repair with superior load-to-failure properties compared with other fixation methods and with theoretically lower concern of tunnel compromise and fracture.[14,19] Our group has previously described the dual cortical button fixation technique for the ulnar and humeral sides.[4] A variation of this technique was later published but without clinical outcomes.[1] This technique offers a new solution for revision UCL reconstruction but is also attractive as a reproducible, bone-conserving, primary reconstruction option. However, no clinical series has been published on this technique to date. This study reports the clinical outcomes, with minimum 2-year follow-up, on the use of dual far cortical button suspension for UCL reconstruction in athletes.

Materials and methods

This is a retrospective case series of UCL reconstructions. Between 2011 and 2016, we performed 27 consecutive UCL reconstructions with the use of ulnar and humeral-sided far cortical button suspension fixation (Arthrex Distal Biceps Button; Arthrex, Naples, FL, USA). After exclusion of those with less than 2 years of follow-up, 23 patients were evaluated. Data were collected from the electronic medical record and patient telephone calls according to a scripted, Institutional Review Board-approved protocol. Collected data included Disabilities of the Arm, Shoulder and Hand (DASH) scores, visual analog scale (VAS) scores, Mayo Elbow Performance Scores (MEPS), return-to-sport status, the date of return to sport, complications, and subsequent procedures. Objective stability tests and postoperative images were not routinely collected prospectively. The MEPS was computed from patient-reported data and telephone conversations. Descriptive statistics were performed for all data. A 2-sample t test was used to compare preoperative to postoperative data when both were available.

Demographics

The study enrolled 23 patients, with an average age of 19 years (range, 14-31 years) and an average follow-up of 47.2 months (range, 24-81 months). There were 5 female and 18 male patients. Most patients were competitive amateur athletes in baseball, gymnastics, and wrestling, with 47.8% (11 of 23) collegiate level, 43.5% (10 of 23) high school level, and 8.7% (2 of 23) competing at the recreation level (Table I).

Operative technique

The operative technique has been previously described in detail.[3] Briefly, the patient is positioned supine with the entire arm (and additional autogenous donor site) prepared and draped. The limb is exsanguinated and a tourniquet inflated. After hamstring or palmaris tendon autograft harvest, a traditional flexor-pronator split is performed under tourniquet control.[21] The autograft is pretensioned, then doubled or quadrupled and sutured at either end with high tensile nonabsorbable suture to obtain a 4-mm to 5.5-mm graft. A cortical button is positioned onto the sutures at either end (Fig. 1). The sublime tubercle is identified.

Table I Patients' primary chosen sport of participation preoperatively

Sport	No.	Percent
Baseball—all pitchers	15	65.2
Gymnastics	3	13.0
Wrestling	2	8.7
Javelin	1	4.3
Basketball	1	4.3
Cheerleading	1	4.3

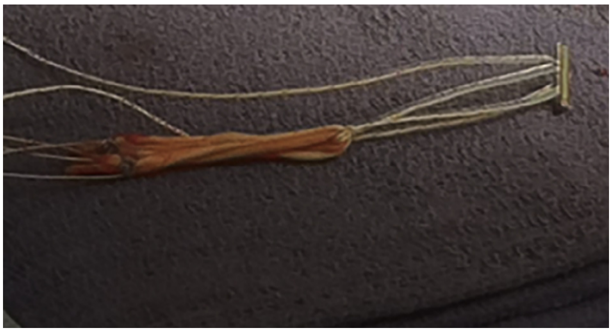

Figure 1 Quadrupled graft construct.

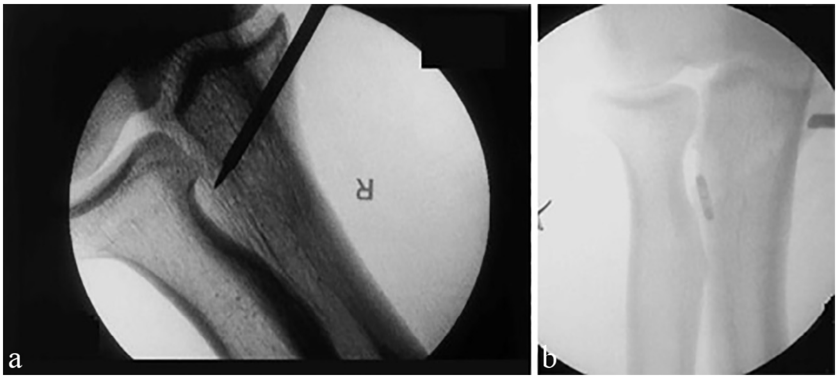

Figure 2 Intraoperative anteroposterior fluoroscopy imaging demonstrates (**a**) the spade-tipped reamer placed bicortically from the sublime tubercle and aimed distal and just posterior to the proximal radioulnar joint (**b**) and confirms successful button placement on the outer aspect of the far cortex of the ulna, outside with the proximal radioulnar joint.

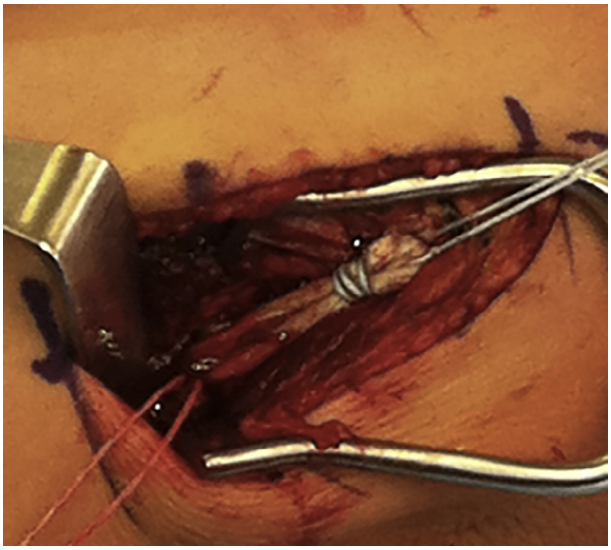

Figure 3 Intraoperative image of ulnar fixation.

A spade tip guide pin is advanced bicortically, under fluoroscopic guidance for confirmation, aiming distal to the proximal radioulnar joint (Fig. 2, *a*). A cannulated reamer matching the size of the ligament graft is drilled unicortically (typically 4.0-4.5 mm in diameter). The ulnar socket is typically 10 mm to 20 mm in depth, striving for a minimum depth of 10 mm for graft docking. The reamer is removed, and the graft is docked distally and advanced into the ulna (Figs. 2, *b*; 3).

Next, the humeral isometric point is identified at the junction between the distal portion of the medial epicondyle and the medial edge of the trochlea. The guide pin is placed from this location across the spool of the distal humerus bicortically, triangulating towards the surgeon's finger on the lateral epicondyle. A cannulated reamer is used (typically 4.5-5.0 mm diameter) to create a tunnel 1 cm longer than the remaining graft. Because the width of the humeral epicondylar axis is 59 mm, the humeral socket depth may vary between 15 mm and 40 mm, depending on the length of the graft and the desired tension.[23] We aim for 15 mm minimum graft docking in the humeral tunnel.

Although we have not experienced articular surface violation, the surgeon should stop reaming and reassess the graft length if subchondral bone is encountered sooner than expected. The second cortical button is advanced bicortically, and the humeral tunnel socket is used to remove any slack after the ulnar side of the graft has been fixed. The elbow is placed in 15° to 20° of flexion and a slight varus force by placing a bump under the wrist. The graft is reduced into the tunnel. Maximal tensioning of both tunnels in this position will result in physiologic tendon tension.[3] The sutures are locked into the graft and sequentially tied. One limb of each suture is then passed through the graft in a running, locking fashion that also incorporates the underlying native UCL in the construct as a nonbiologic augmentation. Once the sutures are passed through the graft on both humeral and ulnar sides, they are tied at each end.

The tourniquet is released, and meticulous hemostasis is obtained before closure and bandages. The patient is immobilized for 5 days in a splint for pain control. Standard images are obtained in the clinic at 6 weeks (Fig. 4). A standard progressive rehabilitation program is followed, with a goal of return to sport at 10 to 12 months.

The primary outcome was return to sport. Secondary outcomes included the DASH score, range of motion, and complications. Also collected were additional data on demographics, hand dominance, sport, level of play before and after injury, additional procedures, graft type and location, postoperative MEPS, and preoperative and postoperative VAS.

Results

We included 23 athletes (Table I) who underwent the above technique (21 primary and 2 revision operations) with a mean follow-up of 32.5 months (range, 24-81 months). Follow-up in 4 patients was less than 24 months, and they were excluded. Autograft was used in 22 patients (15 palmaris, 6 gracilis, 1 semitendinosus) and allograft (gracilis) was used in 1 patient (Table II). Eleven patients (47.8%) underwent 15 concomitant procedures, including 3 ulnar nerve transpositions, 1 ulnar nerve neurolysis, 3 arthroscopic shoulder posterior capsular releases, 3 olecranon osteophyte excisions, 1 elbow contracture release, 2 flexor-pronator mass repairs, 1 olecranon bursectomy, and 1 glenoid labral débridement.

Overall, 82.6% (19 of 23) of patients returned to sport at an average of 11.1 months from the operation. Specifically,

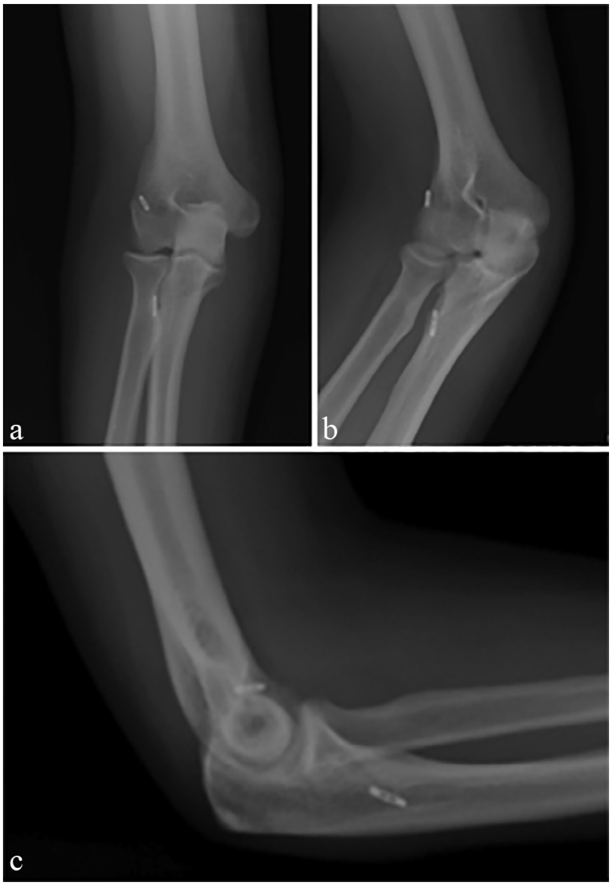

Figure 4 Radiographs of the elbow in (**a**) anteroposterior, (**b**) oblique, and **(c)** lateral views show appropriate button positioning and a concentric elbow.

Table II Ligament graft chosen for ulnar collateral ligament reconstruction

Graft choice	No.	Percent
Palmaris autograft	15	65.2
Gracilis autograft	6	26.1
Semitendinosus autograft	1	4.3
Gracilis allograft	1	4.3

69.6% (16 of 23) returned to the same level or better, and 13% (3 of 23) returned to a lower level (none related to elbow function). Four patients (17.4%) did not return to sport because of poor elbow function in 1, UCL reconstruction failure in 1, shoulder pathology in 1, and a change in profession unrelated to the elbow in 1 (Tables III, IV). At final follow-up, the average DASH score was 3.8, MEPS was 94.1, and range of motion averaged 0° to 140°, with 87% (20 of 23) of patients achieving full motion compared with the contralateral side and all having the same or better motion than preoperative levels. The VAS score improved from 3.8 preoperatively to 0.2 at the final follow-up ($P < .0001$).

Transient postoperative ulnar neuritis developed in 3 patients (13%), all of which resolved at an average of 2.3 months (range, 0.83-4 months). New ulnar symptoms developed in a fourth patient 1-year postoperatively and required neurolysis. Three patients (13%) required return to the operating room for 4 total procedures: 2 for removal of symptomatic humeral buttons, 1 arthroscopic removal of a humeral button that migrated intra-articularly, and 1 ulnar nerve neurolysis. All patients with subsequent button removal successfully returned to sport at the same or better level. There was 1 (4.3%) graft failure.

Table III Rate of return to patient's preoperative sport of choice stratified by postoperative level of play compared with preoperative level

Return to sport	No.	Percent
Same or better	10	69.6
Lower	3	13.0
No return	4	17.4

Table IV Rate of return of pitchers stratified by postoperative level of play compared with preoperative level

Return to pitching	No.	Percent
Same or better	10	66.7
Lower	1	6.7
No return	4	26.7

Discussion

This is the first patient series reporting clinical outcomes for the far cortical button suspension technique on both the humeral and ulnar locations. The rate of return to sport was 82.6%, but there was a 13% attrition to lower levels, and 17.4% did not return. The current literature reports an 82% to 92% return to sport at the same or higher level after UCL reconstruction.[5,8,17,18,20,24] Only 2 patients blamed their elbow for their decreased performance, including 1 late ligament rerupture. Other athletes failed to return due to ankle, knee, and shoulder injuries or the decision to stop playing for reasons unrelated to the injury. Interestingly, due to our academic referral practice, our cohort was made up of mostly collegiate and high school athletes. Several authors have described lower rates of return to sport in nonprofessional athletes compared with professionals. This phenomenon could account for 5 of the 7 patients who did not return to the same level despite excellent clinical elbow function.[5,20]

Even including those who did not return to sport, functional results were excellent, with an average DASH score of 3.8 and MEPS of 94, with 87% of patients achieving symmetric motion (all well within the functional arc). This technique theoretically requires much less dissection proximally and distally than the docking techniques because only 1 tunnel is needed on each side. For us, this simplifies the operation and theoretically allows less retraction and scarring. This perhaps explains the relatively low rate of transient

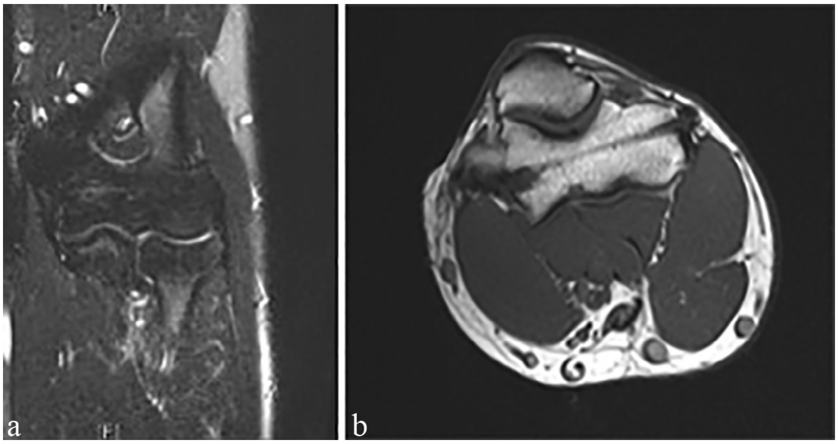

Figure 5 (**a**) Coronal T2 magnetic resonance imaging shows ulnar collateral ligament graft incorporation. (**b**) Axial T1 magnetic resonance imaging shows the humeral button suspension across the metaphysis.

ulnar neuropathy of 13%, which is similar to the current literature.[24] Although longer grafts are associated with proportionally more "creep" or elongation, we believe this can be minimized with pretensioning and protection of the graft with nonbiologic augmentation with nonabsorbable sutures incorporated into the construct. In this setting, the long length of graft within the tunnel may increase the opportunity for graft healing (Fig. 5).

Concern over risk of fracture and solutions to bone loss seen in revision cases of UCL reconstruction have prompted several modifications over time since the original figure-of-8 technique by Jobe et al.[7] A recent systematic review that compared several techniques found the docking technique had a clinically higher return to play and lower complication rate than the Jobe and modified Jobe techniques as well as a lower medial epicondyle fracture rate, which was not shown to be statistically significantly.[24] The same study looked at failure mechanisms and showed the docking technique fails at the suture, the Jobe technique fails at the ulnar tunnel, and the interference screw fails primarily by ulnar tunnel fracture.[24]

Cortical button suspension offers an alternative solution to bony insufficiency in the revision situation and creates a single tunnel fixation strategy in primary reconstructions. Armstrong et al[2] performed a cadaveric biomechanical comparison between native, docking, ulnar cortical button fixation, interference screw, and figure-of-8 fixation. They showed peak load to failure was similar between docking and cortical button suspension techniques, both of which superior to interference screw fixation and figure-of-8.[2]

Lynch et al[12] compared ulnar tunnel cortical button fixation to docking and the native UCL in 7 cadavers and found no difference in elbow kinematics. Cortical button fixation had similar load to failure but displayed less laxity and joint gapping than the docking technique, and the authors noted less dissection was required because only 1 ulnar drill hole was needed.[12] The same group compared the docking technique with a variant of the dual-cortical button technique in a similar study and found similar kinematics but lower ulnohumeral joint gapping in the cortical button technique.[13]

Similarly, Morgan et al[15] found no difference in ulnar sided load to failure between cortical button suspension and the docking technique supplemented with an interference screw. Jackson et al[9] compared the docking technique with a dual cortical button technique and showed no significant difference in stiffness, ultimate torque, ultimate torque angle, or energy absorbed. Lee et al[11] created a revision model to study a hybrid technique (ulnar cortical button suspension technique with humeral docking technique) in the setting of ulnar cortical bone loss. Load to failure was comparable to historical data for the Jobe, docking, modified Jobe, and suture anchor techniques.[11]

Overall there is convincing biomechanical data supporting cortical-button suspension fixation as a viable fixation option for UCL reconstruction. Biomechanical studies do have shortcomings: specifically, they do not assess healing, complications, or functional outcome. In an effort to bridge this gap, this study provides the first report of clinical outcomes using this dual-sided, single-incision, far cortical button suspension technique.

One downside of this technique is the superficial nature of the lateral humeral button. We discuss with our patients preoperatively that delayed removal of symptomatic hardware under local anesthesia is possible, as was the case in 13% of patients. Interestingly, the humeral button in 1 of these patients had migrated intra-articularly at 25 months postoperatively after new onset of mechanical symptoms, despite excellent function and return to sport. This was removed arthroscopically without sequelae. Button irritation did not seem to affect function, because the 3 patients who required removal of hardware returned to the "same or better" level. Moving the trajectory more anteriorly in thin patients will shorten the humeral tunnel, yet prevent the button from being palpable.

One (4.3%) reconstruction failure occurred, accounting for half of the patients who did not return to preinjury level due to elbow function. This occurred at 15 months postoperatively in his first game back at the collegiate level. The nature of the mechanical failure is unknown because this patient's interests had changed from overhead sports, did not affect his everyday activities, and he did not return for follow-up.

Because of the small size of our study, comparing our failure rate to the literature is difficult, which is best defined by Cain et al,[5] who noted 1% revision surgery in their large study. A future larger study will help determine the failure rate more accurately.

Another weakness of this technique is cost. Cortical button technology is currently costly and may be inhibitory in some practices, but we expect these costs to normalize over time as competitors emerge. Further, this cost could be recuperated by surgical efficiency and clinical reproducibility compared with less expensive techniques.

This study has several weaknesses. First, it is an observational study with no randomization of reconstruction techniques. As with most retrospective studies, we did not specifically examine the patient preoperatively or postoperatively for the purpose of the study. Our practice is to include range of motion and other variables, such as pain, in routine postoperative examinations, but some objective tests, including late stability examinations and late radiographs, were not routinely justified or performed.

We were unable to adequately collect preoperative functional scores for comparison with our patients' final outcome. Although we are unable to state statistical significance for these variables, we believe these results are clinically significant and generalizable to most sports and upper extremity surgeons. As a result of the relatively small cohort size, it is difficult to accurately compare our outcomes with those of more traditional techniques that have undergone much larger studies.

Our study cohort consisted entirely of amateur athletes, making the results difficult to generalize to professional level athletes. Also, this was a mixed group of athletes participating in different sports, each with unique demands on the elbow; thus, the results of the group may not be generalizable to throwers and overhead athletes. Despite these weaknesses, this study represents a first report of a new technique with good functional results and return to sport.

Conclusion

The humeral and ulnar cortical button fixation technique provides a new UCL fixation option with theoretically lower concern for tunnel fracture and with similar return to sport and functional outcome as reported in the current literature of more traditional techniques.

Disclaimer

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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