SPORTS CHIROPRACTIC POST-SURGICAL REHABILITATION OF AN ELBOW FRACTURE DISLOCATION FOLLOWING A BRAZILIAN JIU-JITSU INJURY: A CASE REPORT

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Abstract

Background: Term 'the terrible triad of the elbow' describes posterior dislocation with fracture of radial head and coronoid process, and tear of lateral collateral ligament (LCL) complex. This type of injury is historically known to be a challenging injury to rehabilitate. This paper presents a case of the "terrible triad" type injury acquired by a Brazilian Jiu-Jitsu (BJJ) practitioner during a training session and who received chiropractic post-surgical rehabilitation.

Case presentation: A 26-year-old Asian male injured his left elbow during BJJ training session. After transport to the hospital, closed reduction in the emergency was attempted twice but failed to reduce radial head dislocation. Later, CT scan revealed a tear of the LCL complex and a fracture dislocation of the radial head.

Intervention and outcome: The injury was managed surgically via open reduction and internal fixation procedure. The patient chose to receive chiropractic post-surgical rehabilitation. The outcome of treatment was measured using patient reported outcome measures and achieved desirable outcome after 12 weeks of management which consisted of total 15 treatment sessions. The elbow motion arc improved from 60° (extension 60° - flexion 120°) to 150° (extension 5° - flexion 155°). His Disabilities of the Arm, Shoulder, and Hand score improved by 78.3 points, Patient Rated Elbow Evaluation score increased by 61 points, and Upper Extremity Functional Index achieved a full score.

Conclusion: This report discusses the post-surgical chiropractic rehabilitation of a unique BJJ-related injury. Despite the limitation of available literature to guide development, multimodal chiropractic rehabilitation can be successful in post-surgical rehabilitation.

Keywords: Elbow, surgery, rehabilitation, sport, chiropractic, FAKTR, BJJ

Background

Elbow dislocation injury has an annual incidence of 5.2 cases per 100,000 person-years, and complex dislocation has an incident rate of 2.5 to 2.8 per 10,000 person-years[1-3]. In complex dislocation, up to 14% of posterolateral dislocations involve radial head fractures, which often accompany associated injury of the lateral collateral ligament (LCL) complex, and fracture of radial head and coronoid process[1, 3-5]. This type of injury is termed the "terrible triad of the elbow" with historically poor outcomes[5]. The most common complications are loss of range of motion, persistent instability, and severe osteoarthritis[6, 7]. Currently, falls are the main cause of elbow dislocation injuries, and football or rugby has the highest incidence of elbow dislocation among other sporting events[2].

This injury is described here in a Brazilian Jiu-jitsu (BJJ) practitioner. BJJ is a fast-growing combat sport with a unique grappling style that mainly involves submission holds[8-10]. It features prominently within other mixed martial art (MMA) sports including Ultimate Fighter Competition (UFC). Despite the growing popularity, the existing knowledge of BJJ-related injuries is poor[8, 11, 12]. One study assessed an injury rate during the BJJ competition suggests 78% of injuries are orthopedic injuries and the elbow is the most commonly injured location, but the literature indicates only one case of dislocation during the competition[8]. In this paper, we present an acute "terrible triad" type injury from BJJ training and multimodal post-operative chiropractic management.

Case presentation

History

A 26-year-old Asian male injured his left elbow during a BJJ sparring session. The patient and partner, who were both novice practitioners were engaged in the mixed standing and sitting positions, attempting to dominate the grappling position. The partner of the injured patient was attempting to 'sweep' the patient when he resisted the sweeping force by pulling himself out of a transitional position (See Picture. 1 and 2). The partner had a grip on the patient's elbow and contralateral sleeve. When the patient was being swept by the opponent, the patient's clothing (gi) slipped, catching the patient's elbow. The momentum of the body weight of the patient when he was being thrown forward was resisted by the thick material of the gi. This momentum causing a distraction force at the elbow joint. In BJJ technique, a sweep is a sub-category of a takedown, which uses a distinct mechanical force to break the opponent's balance and posture by applying push and pull forces simultaneously. Usually, the sweep is considered to be low amplitude and low velocity compared to takedown. However, the technique, in this case, was clumsy, as the patient attempted to balance himself whilst resisting a fall to the floor, causing a large distractive force. At that moment, the patient heard a loud cracking sound from his elbow and was not able to move his arm (See Picture.3 and 4). A senior chiropractic intern, who is also an experienced BJJ practitioner attended the scene. The student consulted his clinical supervisor regarding the patient examination and injury management.

On examination, the elbow was visibly displaced posteriorly. The patient was unable to move the elbow. Sensation distal to the elbow and radial pulse were normal, initially and whilst being transported to hospital (See Picture.5). The patient was taken to the local emergency department by the student chiropractor and his BJJ partner. X-ray showed posterior dislocation of the elbow with radial head fracture (See Picture.6 and 7). Closed reduction of the elbow was attempted twice under full sedation and immediately immobilized with plaster. Propofol and micro-dose of fentanyl were used for pain and relaxation but the pain from the attempt at a closed reduction was severe enough to wake the patient. Post reduction x-ray showed that the ulna was successfully reduced but the radial head failed to properly align. A subsequent CT scan revealed a radial head fracture and torn joint capsule and ulnar lateral collateral ligament (ULCL) injury. An operation was performed to correct these defects two days after the accident. According to the surgical note, a lateral approach was used. The radial head was successfully reduced by open reduction and internal fixation (ORIF) with a reconstruction of ULCL and the annular ligament. The patient was discharged on the same day with a sling, and non-steroidal anti-inflammatory drugs (NSAIDs) and oxycodone to manage the pain.

Past medical, family, and psychosocial history

Two weeks after the operation, the surgeon referred the patient for post-operative rehabilitation. The patient chose to see the student chiropractor for rehabilitation. This decision was due to the patient's language barrier, and because the student chiropractor had an extensive experience in BJJ. For the following management, the student chiropractor discussed all management with the clinical supervisor who is an experienced sports chiropractor.

On the initial encounter after the operation, history and general physical examination were performed. The past medical, family and psychosocial histories were unremarkable.

Assessment

The patient was wearing a sling and flexible cast to limit flexion of the elbow to 90° for 13 days. On initial physical examination, the range of motion (ROM) of the non-injured elbow was recorded as a baseline (See Table 1). His left elbow exhibited disuse atrophy, edema, bruises, and elbow flexion was markedly restricted (120°) with pain which was exacerbated by active movement of the elbow. Palpation of the affected limb revealed general tenderness over the forearm and upper arm including biceps, brachialis, and common flexor and extensor muscles. The incision site was warm to touch. At that time, the patient reported generalized stiffness and weakness of the arm.

Patient-reported outcome measures (PROMs) were documented on the initial visit, and again on the sixth, eighth-, and twelfth weeks post-surgery (See Table 2). PROMs consisted of the: Disabilities of the Arm, Shoulder, and Hand (DASH), Patient Rated Elbow Evaluation (PREE), and Upper Extremity Functional Index (UEFI) questionnaires. Both the PROMs and ROM had a significant improvement by the end 3-month multimodal management program.

Management

For the first two weeks after the operation, the elbow was immobilized and flexed to 90º by a cast and supported by a sling. During this time, the pain was managed with NSAIDs, paracetamol, and oxycodone.

The first patient follow-up with the surgeon occurred two weeks after the operation. After an x-ray evaluation was performed, the surgeon confirmed that the surgery was successful and recommended the patient start rehabilitation exercise. The surgeon gave initial instruction for rehabilitation which was followed by the patient and the chiropractic student. The patient was required to avoid end-range supination and extension, and overhead exercise should begin from the supine position. As recommended, rehabilitation exercise and treatment began from the third week (See Table.3). The exercises were performed in a supine position under the senior student chiropractor's supervision. The overhead exercise was performed in supine with shoulder flexed at 90º. The overhead position minimizes separation of the elbow joint and incorporates triceps muscles to prevent the patient from developing flexion contractures[13]. The application of the early supination and extension exercises is contraindicated because they may stress the reconstructed lateral ligamentous complex, interrupting the normal course of tissue recovery and increasing the risk of re-injury[13]. AROM shoulder flexion in the pronated arm, active pronation, and supination with the elbow flexed at 90º should be used instead[13]. In addition to AROM exercise, gentle instrument-assisted soft-tissue manipulation (IASTM) was introduced to assist the movement and improve soft-tissue glide using the "Functional and Kinetic Treatment with rehabilitation" FAKTR technique. The amount of pressure applied using IASTM was controlled by the patient's pain rating scale. The patient's verbal response of a maximum 4 out of 10 pain rating was tolerated for the initial treatment. The use of IASTM helped reduce swelling quickly (total 10-12 minutes application) and also improved subjective stiffness and pain. The direction of the stroking movement of the instrument was moving away from the incision to disperse the swelling. This resulted in visible improvement in skin colour and peripheral circulation of the hand. The initial goal of management was to increase elbow ROM, whilst managing/minimizing pain and swelling. The home exercise program was discussed in the initial appointment (See Table.4).In the fourth week, the patient presented with bilateral shoulder and neck discomfort, but the elbow ROM and pain had improved substantially. Elbow active ROM (AROM) increased in flexion from 120º to 150º and extension 60º to 10º (See Table.1). The incision site was still warm to the touch, and the patient had maximal pain at the tip of the olecranon. Throughout the treatment and exercise, pain intensity was monitored by Numeric Pain Rating Scale (NPRS), and approximately NPRS 4 out of 10 was well-tolerated by the patient. Treatment continued with supine AROM exercises, and mid-range isometric contraction with mild to the moderate effort was introduced. Bilateral shoulder pain was due to painful tightening of shoulder girdle muscles including levator scapulae, trapezius, and rhomboids as determined by palpation and range of motion testing of the shoulder. This was believed to be due to the overactivation of shoulder girdle muscles to compensate for restricted forearm ROMs and avoiding weight-bearing of upper limbs. Decreased thoracic and

cervical ROMs with increased thoracic kyphosis were also noted. To reduce muscle tension and restore normal ROM, soft-tissue manipulation including pin and stretch mobilization, IASTM, and trigger point therapy were applied. This resulted in full pain-free cervical and thoracic, shoulder ROMs. For home advice, stretching of pectoralis muscles against a wall, wall-angels as tissue sparing exercise, and thoracic extension over foam roll were prescribed.

In the fifth week post-operation, the patient reported a marked improvement of pain, stiffness, and ROM in the elbow, neck and shoulders. The difficulty level of exercise was increased by adding resistance bands and increasing the complexity by the combination of trunk, shoulder, elbow, and wrist movement. Care was taken not to force the recovering tissues with excessive force during the healing post surgery. The intensity of pain and discomfort tolerated during the exercises was set at 4 out of 10 verbal rating pain scale. The patient did not notice significant pain or discomfort during exercise, however, there was an apprehension associated with extending the elbow. The patient was instructed to hold a long stick with both hands and lightly hit targeted objects, and the targets were constantly moving randomly; this multi-joint movement required external focus on the task and alternating supination and pronation of the forearm. The patient began weight-bearing exercise earlier than expected. This is not a popular choice for elbow post-operative exercise, and usually initiated 6 weeks after the surgery[14, 15]. However, weight-bearing of upper limbs was the essential movement for BJJ, and an early introduction of sport-specific movement patterns into the rehabilitation program can reduce deconditioning[16]. From a quadruped position, the patient was instructed to perform weight-bearing onto his elbow by shifting the bodyweight back on forth in a rocking motion. This active self-controlled weight-bearing exercise helped the patient overcome the fear of pain and re-dislocation by a progressive application of controlled loading to the elbow joint. By the end of the fifth week, the patient was able to perform the concentric exercise with a resistance band. The concentric elbow exercise was performed in supination coupled with shoulder retraction and protraction to restore normal movement patterns. This approach was continued for the next two weeks.

Eight weeks into the post-operation, the patient had a scheduled follow-up with the surgeon. The patient was given permission by the surgeon to perform full ROM with supination, especially extension with a supinated forearm. After clearance, slow progressive loading of tissues for physical and psychological reasons was recommended. Eccentric strengthening exercises were introduced to improve flexion and extension of the elbow. The literature suggests the introduction of gentle strengthening exercises with both light weights and resistance bands at 8 weeks postoperative when it is likely to attain sufficient tensile strength to stabilize the structures[13]. Although strengthening through full ROM was deemed to be achievable, the patient was apprehensive about reaching the full ROM. An unstable loading exercise was introduced to draw the patient's attention to fulfilling the task instead of focusing on symptoms. The exercise was easily tolerated by the patient and he did not report any lack of strength or fatigue. He did report apprehension associated with using the elbow at/near full extension and was instructed

to move slowly and not exceed 4/10 on a pain scale to limit the force. A 4-8kg of kettlebell suspended on the resistance band (unstable load) was used to do supine press and standing biceps curls (See Picture.8). The unstable load exercise improved the patient's progression significantly. By the end of ten weeks post-surgery, the patient reported minor pain around the olecranon only after rehabilitation exercises. Stiffness and discomfort were noted at the end range of both flexion and extension, which was worst after prolonged rest and improved with rehabilitation exercises and rest. Incorporating IASTM during resistance exercise using the principles of the FAKTR technique[17] (See Table.5) helped achieve full elbow ROM and reduced the patient's awareness of stiffness and apprehension when reaching the end range of movement.

Upon completion of 12 weeks post-surgical rehabilitation which was consisted of a total of 15 treatment sessions, the final assessment was performed on the last scheduled appointment. The patient was able to move his elbow freely without any apprehension or pain. Elbow ROMs was restored to normal (compared to the opposite elbow) value except for extension and supination, restricted by 5º. Prior to the operation, the surgeon informed the patient that loss of ROM is expected following the surgery that this is within the acceptable range of 0º - 20º. Around 12º-20º loss in extension is expected after the surgery, which spares a functional arc of elbow motion (30º extension to 130º flexion)[18-20].

When comparing the lateral surgical repair approach to the combined lateral and anteromedial approach, the lateral approach has a less favourable outcome of restoring full ROM[21]. Hence, the outcome of the patient's elbow ROM, in this case, was considered successful. The patient completed three months of PROMs and the results were compared with the initial outcomes. The patient had a significant improvement in PROM evaluation within three months; DASH scores improved from 80.8/100 at initial evaluation (IE) to 2.5/100 in three months, the UEFI score from 19/80 at IE to achieving a full score of 80/80, and PREE score from 80.3/100 at IE to 8/100. The patient reported that he was able to return to training for tennis competition and did not return to training for BJJ for 12 months post-surgery. Returning to BJJ training typically takes a further 6-9 months for additional sports-specific rehabilitation and training to return to sport (personal observation author one) however, an average of 153 days has been noted for return from radial head arthroplasty from injury in sport (not specifically BJJ) with 47% not returning to full sport function[22]. Additionally, 9 of 15 patients resumed full upper limb function in the military following radial head arthroplasty, which included six terrible triad injuries[23]. Almost a year after the surgery, the patient visited the chiropractic student before he returned to his country. The patient was free of complications and gained full function. The patient had returned to the sport, actively competing in BJJ and local tennis competitions.

Discussion

The elbow dislocation injury is categorized into simple or complex types. A simple dislocation involves capsuloligamentous injuries without any bony pathologies, whereas

a complex dislocation usually accompanies fractures[3]. Fracture of the radial head is one of the most common elbow fractures, with an incident rate of 2.5 to 2.8 per 10,000 person-years, and up to 14% of posterolateral dislocation involves radial head fractures[1]. In posterolateral dislocation of the elbow, avulsion of lateral ulnar collateral ligament (LUCL) from the lateral epicondyle occurs firstly, fracture of radial head follows secondly, and these are followed by coronoid fracture as the ulna dislocates posteriorly[4]. This posterolateral rotatory mechanism producing this group of injuries is termed the: "terrible triad of the elbow", which is known to have poor post-surgical outcomes[3, 5]. The most common complications following surgery are recurrent valgus instability and severe osteoarthritis[5, 24]. Up to 80% of these "triad" cases have ligamentous injuries associated with the radial head fracture, but clinically relevant cases account for only 11% with a lateral collateral ligament (LCL) complex and 1.5% of a medial collateral ligament (MCL) injury[1]. The primary stabilizers of the posterolateral elbow are the LCL complex and annular ligaments, and the radial head has a critical role as a secondary stabilizer[3, 25, 26]. The integrity of lateral elbow stabilizers is important in upper extremity movement, as simple shoulder abduction produces a significant amount of varus force on the posterolateral part of the elbow[25]. An intact radial head is a key factor for resisting posterior displacement of the elbow. Injury to the radial head has been shown to increase gross instability even when the elbow is flexed[27]. For these reasons, the "terrible triad" type of injury is managed via open reduction and internal fixation procedure in order to achieve optimal stability[3].

The postoperative management of "terrible triad" injury is challenging. The rate of progression is largely dependent on the integrity of soft tissue particularly the primary static stabilizers of the elbow[13, 15]. Three primary static stabilizers are intact integrity of ulnohumeral articulation, MCL, and LCL, particularly ulnar part of LCL has a critical role as a primary static constraint[7]. In the early phase of rehabilitation, some movement must be restricted to prevent excessive stress on the healing capsuloligamentous complex[15]. For instance, repair or reconstruction of LCL complex requires limitation of supination[15, 28]. Managing edema and pain is important as they have a significant influence in the early phase of exercise[15]. Icing before and after any manual therapy is recommended to prevent exacerbation of edema and pain[13, 29]. Patients should perform exercise within the stable range of motion just before the painful range to facilitate early controlled mobilization[13]. Pushing through pain challenges anatomical integrity in the post-surgical phase and procedures that do this should not be attempted until healing from the surgical procedure has been completed and clearance is received from the surgeon. Based on current trends in post-operative rehabilitation, pain limited AROM and active-assisted ROM exercise occur for the first 6 weeks, followed by functional and strengthening exercise from 6 to 12 weeks[14]. Post-operative management for fracture-dislocation of the elbow demonstrates a substantial gap between evidence and practice patterns, hence it is difficult to determine the effectiveness of interventions[14, 30].

BJJ is a well-structured form of martial arts and is considered a fundamental skill in mixed martial arts (MMA). BJJ is no different to any sport in that injuries occur from training and competition. Despite the rapid growth of its popularity, BJJ-related injuries and prevention are poorly studied. A few studies have documented injury patterns and rate, with the knee the most commonly injured body part[11, 31]. One study reported the elbow as the most commonly injured site during the competition[8]. With the best available knowledge, research on BJJ-related injuries is fairly new and literature lacks consistency in findings. The earliest study suggests hyperextension injury of elbow from submission called 'arm-bar' as the main mechanism of the elbow injury[8]. On the contrary, another study surveyed 166 BJJ gyms in the United States revealed that injury to hand and fingers as the most prevalent injury stie[12]. One study sampling 193 participants from 13 BJJ gyms in Brazil reported the shoulder as the most frequently injured site[32]. To date, only one BJJ related elbow dislocation case has been reported in the literature and that was from a fall on outstretched hand mechanism (FOOSH)[8]. Another survey reported that fingers and knee are the most frequently injured body parts for upper and lower extremities, however the data was based on a single gym in Canada[33]. Due to the inconsistency of study designs, the current available data have to be interpreted cautiously. For this reason, direct comparison of data from different studies is difficult.

Modern chiropractic rehabilitation utilizes a multi-modal approach to address a vast range of sports-related injuries[34, 35]. For successful patient care of the sports-related injury, it is essential to have knowledge of sports, sports injury mechanism, and acute trauma management[35]. An injury study based on a single BJJ gym reported that 68% of injured athletes required medical attention, and 15% of those injured athletes required surgical intervention[33]. The data suggests that injury type was not just limited to sprain or strain, severe injury types, such as fracture, laceration, dislocation, and concussion were not uncommon[33]. Unlike other combat sports, BJJ is a submission-predominant discipline that focuses on a submission hold, such as arm-bar and joint locks[9, 10]. This unique concept of BJJ may explain a higher rate of joint injuries compared to striking-dominant disciplines, and 78% of injuries during the BJJ competition were orthopedic injuries[8, 10]. It is important to investigate BJJ-specific mechanisms of injury, and this knowledge should be implemented to assist in injury prevention. Future research should focus on the need to document common injury patterns and the specific BJJ techniques that contribute to them. Knowledge of these practices and their associated injury patterns will inform the teaching of BJJ and the prevention and management of injury in its practitioners.

This case report illustrates the successful multimodal management of an acute fracture-dislocation of the elbow with associated ligamentous injury in a BJJ practitioner, who received a surgical solution and a post-surgical chiropractic rehabilitation program. Successful multimodal chiropractic management enabled the patient to be ready to participate in sport within three months without any significant post-traumatic deformity or complications. This report adds to the available knowledge of BJJ-related injury and post-surgical management of elbow fracture-dislocation injury.

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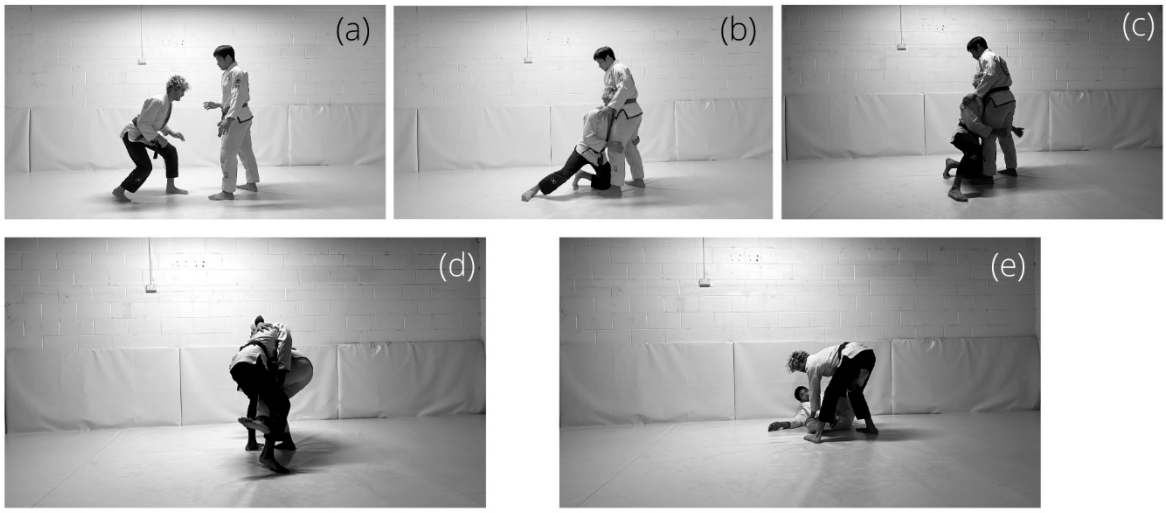
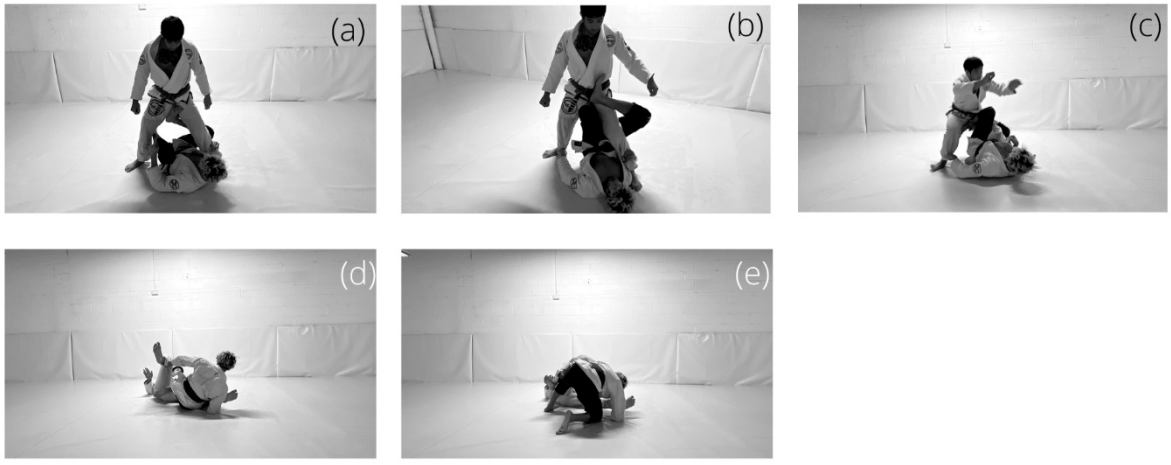
Appendix.1

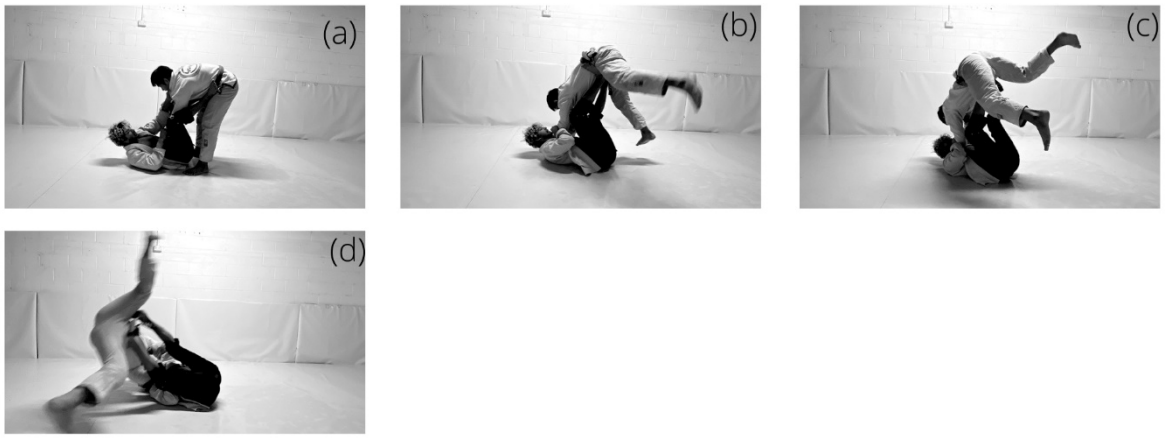
Picture.1 The practitioners are demonstrating double-leg takedown. Note that both athletes begin the match from the standing, and the goal of this technique is taking the opponent to the ground.



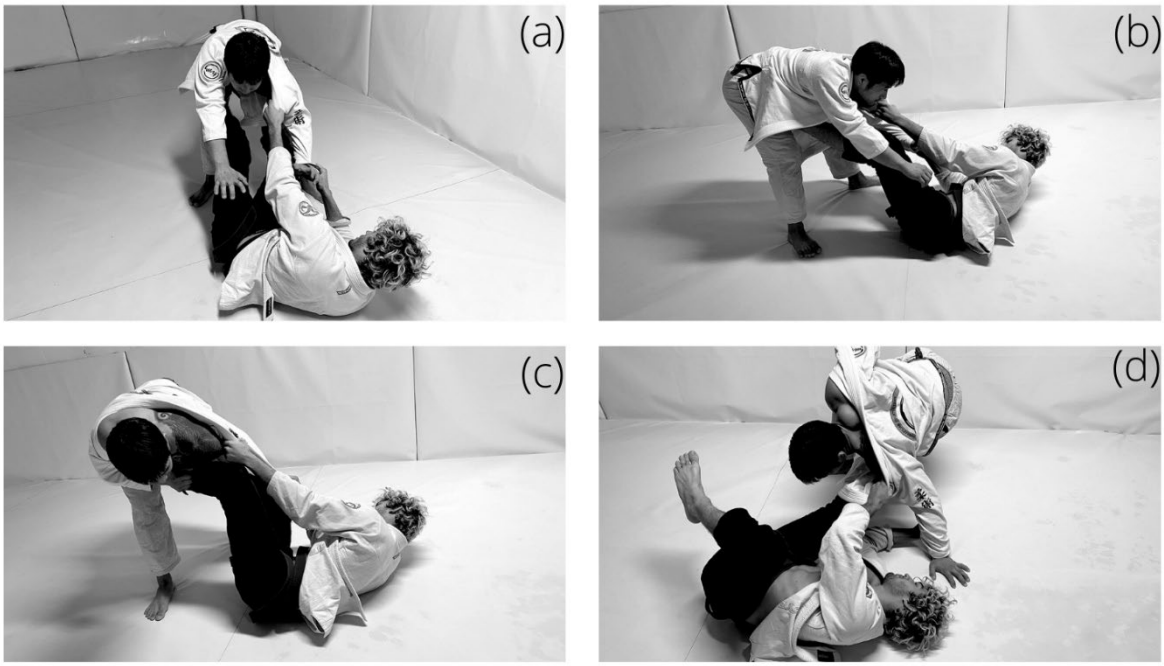
Picture.2 The practitioners are demonstrating sweep technique. In this technique, the athlete at the bottom position, who is on the ground attempts to break the balance of opponent in standing. The goal is a reversal of position, to dominate and secure a safer position in the ground game.



Picture.3 Demonstration of an ideal sweep technique. Note how the practitioner on the bottom manage**s** to ex**e**cute push and pull movements to break the opponent's balance and use the momentum to complete the technique.

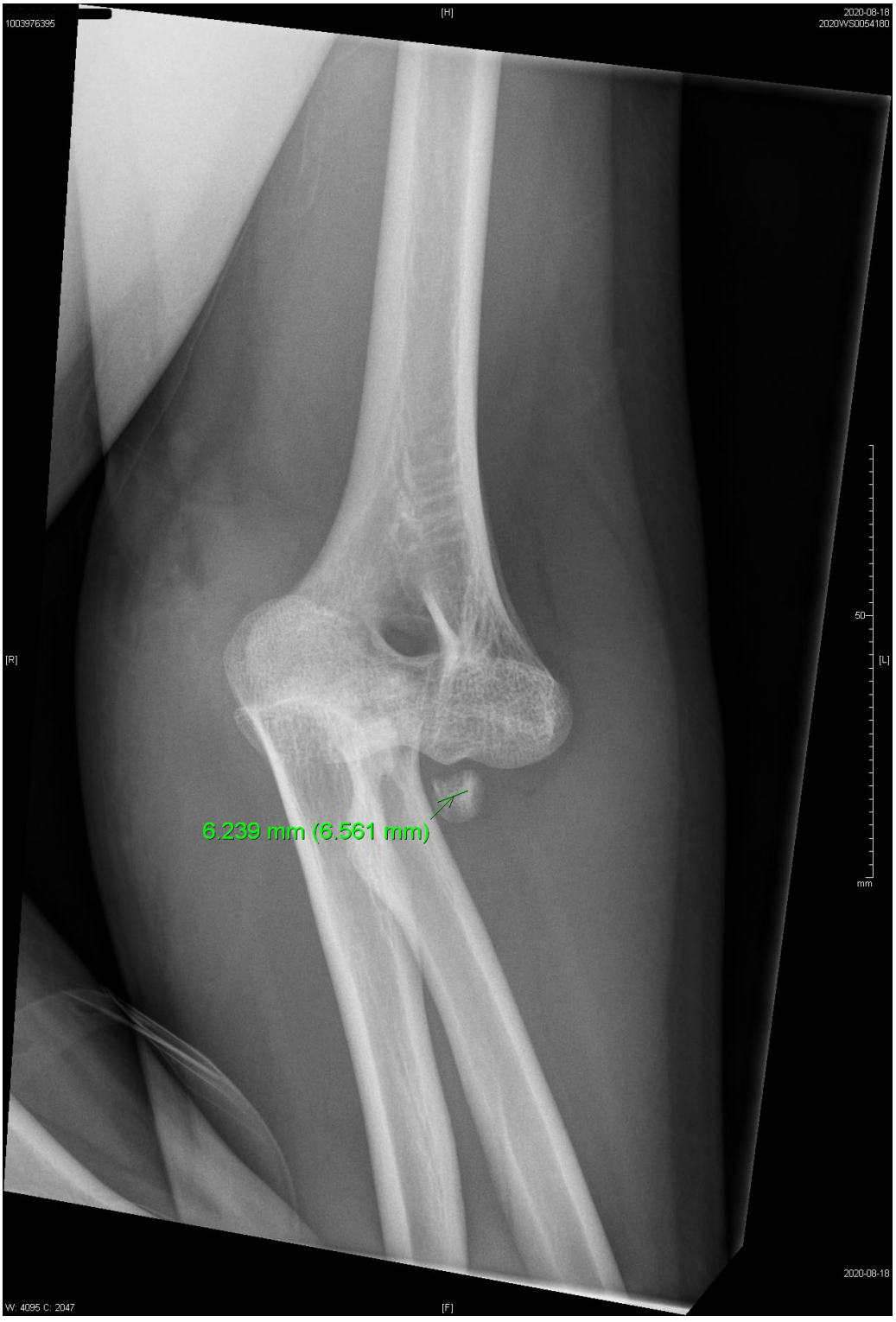


Picture.4 Two practitioners are demonstrating the poor technique described in this case report. (a), (b) note the outstretched arm and shifting of the weight in attempt to escape from the opponent's (person on the ground) pulling force, (c) gi slipped off from the shoulder and getting caught at the elbow, (d) demonstration of the moment when the patient landed on his hand to resist and post himself.



Picture. 5 Post dislocation pre surgery posture of arm

Picture. 6 Fracture dislocation demonstration radial head fracture



Picture. 7 Fracture dislocation demonstration posterolateral dislocation of the elbow

Table. 1- Initial and follow-up range of motion of the elbow

ROMs/Timeline	Baseline R elbow	Week 2 L elbow	Week 6 L elbow	Week 8 L elbow	Week 12 L elbow
Elbow flexion	160	120	150	155	155
Elbow extension	0	60	10	7	5
Supination	90	30	70	80	85
Pronation	90	45	80	90	90

Table. 2 - Patient reported outcome measures (PROMs)

PROMs/Date	5/9/20	26/9/20	28/11/20
Disabilities of the Arm, Shoulder and Hand **(DASH)**	80.8/100	35.8/100	2.5/100
Upper Extremity Functional Index **(UEFI)**	19/80	47/80	80/80
Patient Rated Elbow Evaluation **(PREE)**	80.3/100	20/100	8/100

Table. 3 – Details of rehabilitation exercise

Exercise	Week (after operation)	Resistance type	Repetitions	Description
Active elbow extension and flexion in the pronated forearm	3, 4, 5, 6, 7, 8	Bodyweight	15-20 reps × every 2-3 hours	Caution: use ice immediately after each set to manage inflammation
		Gentle isometric contraction in a neutral range against resistance (week 4~)	10 seconds hold × 3 sets	
Supine overhead active elbow flexion and extension in the pronated forearm with/without contralateral arm support	3, 4, 5, 6, 7, 8	Bodyweight	15-20 reps × every 2-3 hours	Caution: use ice immediately after each set to manage inflammation. This exercise was recommended to perform with the contralateral hand to assist the movement initially.
		Gentle isometric contraction in a neutral range against resistance (week 4~)	10 seconds hold × 3 sets	
Supine overhead active elbow rotation at flexed to 90	3, 4, 5, 6, 7	Bodyweight	15-20 reps × every 2-3 hours	Caution: limit the forearm supination to neutral only in the early phase.
Scapular mobility exercise	4, 5, 6	Bodyweight	15-20 reps × every 2-3 hours	Active scapular retraction and protraction
Wall-angels	4, 5, 6	Bodyweight	12 reps × 3 sets	
Foam-rolling	4, 5, 6, 7, 8	Bodyweight	15 reps × 3 sets	
Stick exercise	5, 6, 7	Dowel (less than 1kg)	15 reps × 5 sets	Holding the dowel with both hands and touching the object as instructed by the therapist. To add complexity and induce more natural movement, moving the target while the patient was trying to reach the object was incorporated.
The weight shifting in a quadruped position	5, 6, 7, 8, 9, 10, 11, 12	Bodyweight	8 reps × 2 sets 12 reps × 3 sets (week 8~)	The patient was instructed to shift weight back and forth to induce a natural weight-bearing on the affected arm. Caution: avoid full extension of the elbow with weight-bearing.

Elbow extension and flexion with resistance band	5, 6, 7, 8, 9, 10, 11, 12	Yellow resistance band (week 5~6) Red resistance band (week 7~8) Eccentric exercise with resistance bands and 1~4kg dumbbell (week 8~)	12 reps × 3 sets	Caution: Supination and extension are acceptable, however, avoid end-range extension of the elbow with the supinated forearm. Watch for compensatory scapular protraction. Full elbow extension with the supinated forearm began at week 8.
Biceps curl with unstable loading	8, 9, 10, 11, 12	Dowel + 4-8kg kettlebell suspended by a strong resistance band	8 reps × 3 sets	The patient holds the dowel with both hands to perform the biceps curl. The full eccentric movement was recommended to restore the elbow extension in the supinated forearm. The kettlebell was suspended in the middle of the dowel by a resistance band.
Bench press with unstable loading	8, 9, 10, 11, 12	Dowel + 4-8kg kettlebell suspended by a strong resistance band	8 reps × 3 sets	The kettlebell was suspended on the non-affected side to create an offset loading.
Forearm rotation	10, 11, 12	Dumbbell 2-4kg	10 reps × 3 sets	Active pronation/supination with the elbow flexed to 90. Instruct the patient to explore the end-range with eccentric control.
Elbow flexion / extension in a quadruped position	10, 11, 12	Bodyweight + green / blue resistance band	10 reps × 3 sets	The patient begins by gently bending and extending the elbow while a weight-bearing and resistance band is wrapping around the elbow to add resistance in elbow extension. Watch for compensatory trunk rotation or scapular elevation, in an attempt, to avoid weight-bearing. Later, this exercise can progress into push-up in the kneeling position.

Table.4 – Home exercise plan

Phase - 1	• Supine overhead (shoulder flexed to 120°-140°and supported by contralateral arm) elbow flexion and extension exercise with pronation. • Ice application to control edema following the exercise. • Avoid active shoulder abduction to prevent the elbow from having excessive varus loading. • Gentle pronation/supination ROM exercise with elbow flexed to 90°.
Phase - 2	• Self-stretching techniques of shoulder muscles, such as, wall-angels and thoracic extension over foam roll. • Active flexion/extension, and pronation/supination exercises. • Avoid combination movement of end range supination and extension. • Elbow isometric strengthening exercise against walls.
Phase - 3	• Strengthening exercises with resistance bands (flexion, extension, pronation, supination). • Strengthening exercises for wrist flexors and extensors • Introduction of closed-chain and weight-bearing exercises through activities of daily living.

Picture. 8 Rehabilitative Exercise with unstable load, performing offset bench press

Table.5 - The 5 FAKTR fundamental concepts[17]

The patient in placed in a position of pain provocation and treatment is applied to the involved region in that position. Treatment initially starts in a static position and progresses through the 5 stages as pain is reduced at each step.
1.Static 2.Movement 3.Resistance 4.Functional 5.Proprioceptive