THE USE OF RELATIVE MOTION SPLINT IN MANAGEMENT OF EXTENSOR TENDON ON ZONE 5-7 USING INTERMEDIATE CONTROLLED MOBILIZATION

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ABSTRACT

Extensor tendon injuries can be challenging to manage due to their complex anatomy, which can lead to functional deficits after surgery. Treatment options include non-operative approaches, primary repair, or tendon grafting. After surgery, a well-structured postoperative program is essential for successful outcomes. This program includes immobilization, early passive motion, and early active motion. This study evaluates the level of acceptability of the relative motion splint in managing extensor tendon repair of Zone 5-7. The respondents are Occupational Therapists- Certified Hand Therapist from Qatar. The study looked into the applicability, functionality, and range of motion of the relative motion splint. Descriptive developmental designs were used, including cross-sectional, longitudinal, and sequential designs. The findings revealed that Hand therapists had a high level of acceptability of the management of the extensor tendon of Zone 5-7 in terms of its applicability, functionality, and range of motion. They perceived the RME/ICAM splint as easier to utilize and construct, which could be a preferred approach for addressing extensor tendon repair in Zone 5-7. The respondents also found that patients can engage in light and heavy activities while wearing the ICAM splint. Additionally, the ICAM splint enables satisfactory total active motion (TAM) in affected digits compared to early controlled mobilization. To enhance the relative motion splint for managing extensor tendon repair in Zone 5-7 using Intermediate Controlled Mobilization (ICAM), key considerations include refining the splint design for comfort and functionality, providing thorough training to therapists and patients, ongoing monitoring of outcomes, and fostering collaboration between stakeholders for continuous improvement.

Keywords: Extensor tendon, Relative Motion Splint, ICAM splint

INTRODUCTION

Extensor tendon injuries can cause significant impairment and may be challenging to manage due to the complex anatomy of the extensors as any minimum discrepancies in tendon length and tension that may cause significant functional deficits following injury and repair (Mottay, Govender & Mpanza, 2020) (1). Generally, there are three management options available for extensor tendon injuries that involve either non-operative management, primary repair, or tendon grafting (Esquivel et al., 2020) (2). Relatively, postoperative management is imperative to protect the repaired extension tendon. Kumar et al. (2018) (3) emphasize the importance of a well-planned postoperative program for extensor tendon surgical repair. Rehabilitation protocols, as outlined by Wong et al. (2017) (4), encompass immobilization, early passive motion (EPM), and early active motion (EAM). Collocott, Kelly, & Ellis (2018) (5) delineate two subcategories of early active mobilization (EAM): controlled active motion (CAM) and relative motion extension splinting (RMES). Early active immobilization, advocated by Bhattacharjee, Rasheed, & Alex (2021)(6), aids in preventing adhesion formation and enhancing tendon healing, leading to improved postoperative outcomes by the

6th week following repair and faster recovery. Lewis (2018) further discusses the industry's trend towards early active protocols, with early passive methods remaining integral to rehabilitation processes. Key concerns raised by researchers involve maintaining repair integrity and limiting adhesions. Rabbani et al. (2019)(7) noted a shift towards dynamic splinting and early active mobilization over traditional early mobilization post-tendon repair. They found early active mobilization to be superior to immobilization, reducing pain and improving range of motion. Neiduski& Powell (2019)(8) observed greater total active motion (TAM) at 12 weeks in patients older than 30 years with a 2-strand repair using a true active protocol compared to passive flexion. Hirth et al. (2021)(9) highlighted relative motion extension (RME) as the most commonly used approach for postoperative management of zones V and VI extensor tendon repairs. They emphasized the effectiveness of relative motion splints in protecting repaired tendons from rupture or attenuation. Miller & Le (2021)(10) underscored the established use of relative motion splints following extensor tendon repair.

While there's a preference for RME/EAM, Howell, Hirt, & O'Brien (2021)(11) identified implementation barriers such as surgeon preference and hand therapist confidence. However, Collocott, Kelly, & Ellis (2018) (12) suggested that RMES protocols have lower levels of evidence and poorer methodological quality compared to CAM protocols. Nonetheless, the low-profile splints used in RMES protocols appear to minimally restrict tendon function while providing adequate protection for repaired tendons. Considering the consistent use of relative motion splints in the management of extensor tendon repair in zones 5-7, there's a need for evidence-based application due to identified research gaps. However, insufficient data exists on the significant effects of applying relative motion splints in this context, necessitating an evaluation. Therefore, this study aims to assess the relative motion splint's effectiveness in managing extensor tendon repair in zones 5-7. It seeks to determine the acceptability of this management approach in terms of applicability, functionality, and range of motion. Additionally, the study will explore the relationship between the variables and provide insights to enhance the application of relative motion splints in treating extensor tendon repair in zones 5-7.

Objective of the Study

The overall objective of this study was touse of relative motion splint in management of extensor tendon repair of Zone 5-7 specifically, it answered the following sub-problems:
(1) investigate the **l**evel of acceptability of the relative motion splint in management of extensor tendon of Zone 5-7 in management of extensor tendon repair of Zone 5-7 in terms of applicability, level of acceptability of the relative motion splint in management of extensor tendon of Zone 5-7 in management of extensor tendon repair of Zone 5-7 in terms of functionality, level of acceptability of the relative motion splint in management of extensor tendon of Zone 5-7 in management of extensor tendon repair of Zone 5-7 in terms of range of motion
(2) Based on the results of the study, what enhancement can be done to improve the relative motion splint in management of extensor tendon on Zone 5-7 using intermediate controlled mobilization.

LITERATURE REVIEW
Extensor Tendon injuries

Extensor tendon injuries can lead to significant functional impairment if not promptly addressed. According to Zubović (as cited in Kumar 2022), managing these injuries requires a skill set and knowledge base equivalent to that needed for flexor tendon injuries. Extensor tendon damage is a prevalent hand injury among young individuals, with extensor mechanisms being particularly vulnerable due to their superficial location and limited subcutaneous tissue. Successful extensor tendon surgery necessitates a comprehensive understanding of anatomy, precise adherence to surgical principles, clinical expertise, a gentle surgical approach, and a well-structured postoperative care plan.

Abrasions, bites, burns, and physical trauma often result in damage to the hand's superficially located extensor tendons. Flexor tendon problems are frequently diagnosed in the emergency room (ER). As noted by Calabro in Baucher (2022), certain injuries can be managed in the ER, while others require treatment by a hand surgeon in an operating room (OR) at a later time. Extensor tendon injuries are typically classified and treated based on nine anatomical zones on the dorsum of the hand, wrist, and forearm. Neligan (2018) found out that odd numbers designate regions overlying articular structures, while even numbers are assigned to regions between joints. The zones are as follows: Zone 1 (DIP joint), Zone 2 (middle phalanx), Zone 3 (PIP joint), Zone 4 (proximal phalanx), Zone 5 (MCP joint), Zone 6 (dorsum of hand), Zone 7 (wrist), Zone 8 (distal forearm), and Zone 9 (proximal forearm).

Desai (2019) highlighted that the treatment of extensor tendon injuries may necessitate surgical intervention based on the injury complexity and hand zone involved, with the primary goal being the restoration of tendon continuity and function, while early digit motion serves as a secondary objective. Optimal preparation and technique are crucial to achieving optimal results and preventing adhesions and scar tissue formation. In contrast to flexor tendon injuries, extensor tendon injuries pose specific challenges due to their exposure, lack of tendon sheaths, tendency to retract minimally post-injury, and susceptibility to adhesions and shortening, which can significantly impact function and range of motion. Therefore, treatment aims to restore tendon function and continuity.

With injuries that are proximal to the anatomic juncturaetendinum, extensor function may still be preserved distally. Additionally, up to 90% of an extensor tendon can be lacerated and still retain preserved function to gravity, necessitating careful physical examination and wound exploration (Long et al., 2020). Further, Extensor tendon injuries can also be iatrogenic, either as a result of a surgical error or as a side effect of an earlier surgery or medicine (eg, a fluoroquinolone). Extensor tendon ruptures after plating wrist and hand fractures are extensively known, Murphy HA et al. 2019 concurred that ruptures that have been reported after pediatric forearm fractures were treated with intramedullary nails.

The extensor tendons of the hand frequently sustain injuries, with over 45,000 cases reported annually in the United States alone and notably common in Qatar. Tendon surgery poses challenges in balancing repair protection and avoiding immobilization-related complications. During the initial post-repair week, the tendon is in the inflammatory healing stage, relying solely on suture strength to prevent rupture. Traditionally, cautious post-surgery rehabilitation limited motion to prevent adhesions, flexion loss, and contractures caused by immobilization and initial injury stress. To enable safer early mobilization and improve outcomes, various orthoses and rehabilitation programs have been developed. Injuries in zones V and VI, due to

their superficial position and limited soft tissue protection, present particular surgical challenges, historically managed with 3–4 weeks of postoperative immobilization. However, prolonged immobilization increases adhesion risks, delays return to work, and restricts daily activities. An effective treatment plan should mitigate these risks, safeguard the tendon repair, and be straightforward to implement.

Repair of Extensor Injuries

Hart (as cited in Baecher, 2021) elucidated in their study that repairing injuries can be done immediately in the emergency department (ED) or within a 7-day delay. Simple lacerations can be managed in the ED by irrigating and debriding the wound, loosely approximating the skin with interrupted sutures. In cases of delayed repair or when postponement is necessary due to contamination or complexity, it's recommended to place the hand in a volar resting extension splint. Lesions near zone 6 are best treated in an operating room (OR) as they often require extensive tissue exposure for proper tendon reapproximation Baz (2021) observed limited implementation of diagnostic imaging modalities for hand tendon assessment. While plain radiography is useful for bony and articular evaluation, it lacks direct visualization of tendon structures. Baz suggested that MRI, with specialized extremity coils, could serve as a diagnostic tool for tendon assessment, but its use might be restricted in post-surgery patients or those with MRI contraindications. High-resolution ultrasound (HRUS) of the musculoskeletal system is gaining popularity due to its ease, non-invasiveness, and affordability. Advancements in ultra-high frequency probes have improved spatial resolution and image quality for musculoskeletal imaging.

Gitto (2018) emphasized the importance of preoperative evaluation in reconstructive surgery planning for torn tendons. Determining the extent of the tear, whether partial or complete, is crucial, particularly when the tear aligns with cutaneous demarcations of retracted ends, aiding in gap measurement. In line with Lee (2018), 56.7% of hand tendon tears were observed, with 33.3% being complete tears and 23.33% partial tears, aligning with findings of predominance in full-thickness tears via ultrasonography and confirmed during surgery. Among 24 patients, the extensor pollicis longus tendon was most commonly affected, found in 11 patients, with the thumb being the most affected finger. However, contradictory to Lee's findings, hypoechoic areas were only observed in four cases (13.33%) compared to their reported 11. This difference was attributed to the timing of postoperative scanning, as immediate examinations might reveal transient ultrasound findings, such as minimal tenosynovitis, which spontaneously resolved after a few days. Additionally, a paratendinous hypoechoic thin rind of simple fluid was noted.

Amr (2019) conducted primary extensor tendon repair using a four-strand technique with nonabsorbable sutures across all zones except Verdan's zones I, II, III, or IV. Surgical rehabilitation included controlled passive exercises after three weeks of static immobilization to minimize microbial presence around the wound. Incisions were elongated, necrosed tendon margins were excised, and zigzag patterns were employed to prevent scar formation crossing creases or causing contractures. Ethibond sutures (3-0 and 2-0) were used, passing through the volar surface of the proximal (or distal) tendon end and then transversely across to the lateral side. Splinting was applied to specific zones for immobilization. The repair was completed by placing a knot outside the volar third of the tendon and using circumferential running Vicryl sutures (3-0). Wound irrigation was followed by skin closure with loosely placed 2-0 prolene, with divided finger thick dressings and avoidance of restrictive bands during dressing.

Healing process of tendons

Two processes contribute to tendon healing: intrinsic healing involving the tendon and its synovial sheath, and extrinsic healing involving surrounding tissues. Extrinsic healing benefits from cellular and vascular ingrowths. While callus formation aids tendon healing, it can limit mobility, especially in zone 11-V11. Measures like steroids and anti-inflammatory drugs have been suggested to prevent adhesion formation. Microsurgical techniques, new suture materials, and gentle approaches help reduce adhesion risk. Factors like associated injuries and trauma type influence adhesion likelihood. Gelberman (2022) highlighted benefits of protected passive mobilization for tendon strength over total immobility post-healing. Research indicates that tendon cells, or tenocytes, possess intrinsic healing capabilities. Lundberg (2021) demonstrated that isolated flexor tendons, devoid of vascular supply but maintained in synovial fluid, can repair without adhesion formation. Preserving the synovial sheath during tendon restoration procedures is emphasized by Peterson (2020).

Strand Repair Technique of Extensor Tendon Repair in Zone 5-6

Bhattacharjee's (2021) study identified zone 5 as the most commonly affected extensor tendon zone (50%), followed by zones 6 (38%), 7 (7%), and 8 (5%). Patients presenting with hand dorsum injuries underwent a brief history-taking and local anesthetic evaluation. Eligible participants aged 15 to 65 with completely disrupted extensor tendon continuity in zones 5 to 8 were enrolled, excluding those with related fractures or thumb extensor injuries. Surgical repair followed thorough wound cleaning and dressing, with anesthesia administered based on patient need. Soft tissue dissection exposed the damaged tendon, with core sutures and circumferential simple sutures used for repair. Post-surgery, a plaster of Paris slab was applied, and mobilization exercises were prescribed. Patients received training until discharge, continued rehabilitation at home, and attended follow-up appointments for suture removal and further rehabilitation adjustments. The splint was discarded after six weeks, and fist-making exercises were initiated.

According to Strauch (as cited in Wolfe, 2017), post-surgery rehabilitation aims to preserve repair integrity while maximizing mobility. Unlike static immobilization, early mobilization strategies after extensor tendon repair prevent adhesions and promote tendon mobility. This approach facilitates proper alignment of collagen fibrils and DNA synthesis, enhancing vascularity at the injury site to support tendon healing.

Macdermid et al. (2017) noted that extensor tendon repairs in zones V and VI require postoperative protection to prevent rupture or gapping, favoring controlled motion over immobilization. The Relative Motion Extension (RME) method, using an RME finger orthosis, allows for controlled active motion across the repaired tendons. This approach, preferred by therapists globally, includes immobilization, controlled motion with palmar orthosis (IPJs free to move), and dynamic orthosis, showing promising results in cohort and comparison studies.

Relative Motion Extension (RME)

In Hirt's (2021) study, it was found that for postoperative care of finger extensor tendon repairs in zones V–VI, orthoses, particularly Relative Motion Extension (RME) method, are commonly utilized. The study highlights that restricted motion, rather than immobilization, is preferred for these repairs to prevent tendon rupture or gapping. The RME finger orthosis

enables controlled active motion across the repaired tendons and emerged as the preferred method in direct comparative tests. This method combines immobilization with controlled motion using a palmar orthosis (with IPJs free to mobilize) and a dynamic orthosis. Notably, it was identified as the most frequently employed approach in an international therapist survey. According to Collocott (2020), the small RME orthosis, a key component of the RME approach, induces the "quadriga effect." This effect results in increased slackness in the repaired tendon(s) compared to neighboring uninjured tendons. It achieves this by positioning the metacarpophalangeal joint(s) of the injured finger(s) in 15-20° more extension than those of the uninjured fingers.

Dr. Merritt introduced the RME technique in the early 1980s, and over the past four decades, several modifications have been made available to the public. Initially, the original RME approach involved wearing both RME and wrist orthoses concurrently, initially linked by a strap which was later eliminated (Hirth, 2020). Dr. Merritt's intraoperative trials in zone V and cadaver investigations in zones V and VI revealed that incorporating a 20°–25° wrist extension orthosis to an RME orthosis helped reduce strain on tendon repairs. Recent research suggests that the wrist orthosis may not always be necessary, as the RME orthosis alone can be utilized during the day without risking tendon rupture. Two studies immobilized the hand overnight using a volar static wrist-hand-finger orthosis (WHFO) to prevent unintended composite wrist and finger flexion, with participants advised to avoid activities causing such flexion, as indicated by Wong (2020). One case study involving two participants did not use any other orthoses. Neither study reported any ruptures or delays in extension.

According to Hirth (2021), adding a wrist orthosis was deemed necessary only for tendon repairs near the juncturaetendinum or extensor digitiminimi (EDM) repairs. Additionally, no ruptures were reported when comparing outcomes between four and six weeks of orthotic intervention. Flexor tendon repair rehabilitation protocols utilize a combination of active and passive motion to enhance tendon excursion, as mentioned by Klifto(2021). Common methods for treating flexor tendon injuries include the Kleinert and modified Duran protocols. The Kleinert technique involves using rubber bands connected to the patient's fingers to facilitate passive flexion and active extension. In contrast, the modified Duran technique requires complete passive flexion and active finger extension while wearing a dorsal block splint (DBS). Other rehabilitation protocols also exist. With advancements in tendon repair techniques, improvements in the strength and quality of hand tendon repairs are being observed. Some studies have explored the benefits of early active flexion in flexor tendon rehabilitation protocols to enhance tendon glide and excursion, although there is limited high-level evidence to support this approach, as noted by Rigó(2017).

Ahmad (2018) agreed that Zone IV and V are rarely prone to tendon injuries due to the protective anterior presence of the thick transverse carpal ligament. However, in cases of crush injuries, multiple tendons may sustain damage due to the crowded nature of tendons within the carpal tunnel. Additionally, injuries to the palmar branch of the ulnar nerve and the sensory and motor branches of the median nerve are possible. It is recommended to fully open the carpal tunnel to ensure adequate access for healing all lesions. Injuries in zones III, IV, and V can involve the ulnar artery, radial artery, median nerve, ulnar nerve, and various tendons. Proper repair in these zones typically leads to a better prognosis, with full motion expected after six months, as noted by Rogers (2021). Compared to zone II, occurrences of tendon adhesions, tenorrhaphy ruptures, or the need for subsequent tenolysis are uncommon in this zone.

Single-/Double Finger Splint Cast

Okafor (as cited in Lukwinyo, 2018) described an immobilization device commonly utilized in hospitals for general forearm immobilization, reducing the risk of unintentional splint sliding and making it more challenging for pediatric patients to remove the splint voluntarily. This method is based on a flexible finger splint, which is then secured to the hand using plaster of Paris or synthetic plaster alternatives. Depending on the patient's age, either the injured finger alone or, when employing the buddy-tape method, the adjacent finger as well, will be taped to the splint. It is crucial to relax the lateral ligaments to facilitate approximation of the detached extensor tendon. Ideally, the splint should be capable of maintaining the PIP joint in a flexed position while extending the DIP joint.

When constructing the splint, slight hyperextension of the DIP joint is recommended to ensure proper contact of the tendon or bone ends. To facilitate hyperextension without causing undue strain on the joint, a small piece of foam can be placed behind the distal phalanx. Potential adverse effects of cast therapy include rashes, pressure areas, and cast fractures. However, overall, it is a reliable device that restricts movement of the injured digit.

Early Controlled mobilization

Recent studies by Wong (2017) provided compelling evidence that early mobilization following hand/wrist extensor tendon repair leads to improved range of motion (ROM) outcomes compared to immobilization methods. To optimize the benefits of early mobilization while minimizing associated risks, mobilization should be conducted under controlled conditions, as noted by Howell (2019). The development of early controlled mobilization protocols aims to strike a balance between motion and protection, allowing movement of the injured digit while restrained by a splint in the early post-operative period. These protocols for extensor tendon repairs in zones V and VI encompass early passive mobilization (EPM) and early active mobilization (EAM) of the repaired tendon, as highlighted by Evans (as cited in Shirley, 2017). Although all of the protocols utilized in the studies were categorized as EAM, a deeper examination revealed that they could be further broken down into two groups: "controlled active motion" (CAM) protocols and "relative motion extension splinting" (RMES) protocols, Hirth 2021. The results of persons treated using CAM and RMES protocols were not directly compared in any of the trials that were included.

The more constrictive splint design utilized in the CAM procedures was the primary distinction between the various EAM regimens. The RMES protocols used a small "yoke" splint that included only the MCP joints of the injured digit(s), in relatively more extension than the other digits; the uninjured digits were left free, allowing functional use (as cited in Collocott, 2022). This distinction between the two types of protocols can be seen in the use of the CAM protocols, which used a forearm-based splint that included the wrist (Das, 2018)
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Acceptabilityof the management of extensor tendon of Zone 5-7

According toSekhon (2017), acceptability has grown to be a crucial factor in the development, assessment, and use of occupational hand therapist interventions. Say (in Giesen, 2019) concurred that several healthcare interventions have a complicated nature; they may, for instance, be provided at various levels within a healthcare institution or include a number of interrelated components. According to Stok (2017), while acceptability is a

necessary condition for an intervention to be effective, it alone is not sufficient. Both providers (such as patients, researchers, or healthcare professionals) and recipients (such as patients or healthcare professionals) must accept the intervention for its implementation. Xie (2018) further expIained that if healthcare professionals perceive low acceptability in delivering a specific intervention to patients, it may not be administered as intended by intervention designers, potentially affecting the intervention's overall effectiveness. The concept of healthcare acceptability is increasingly recognized across various disciplines within health sciences, including psychology, public health, and health implementation science, as noted by Valiente(2021), Harichund(2019), and Bucyibaruta(2018). However, despite its growing importance, acceptability of healthcare lacks a clear and well-defined definition, remaining poorly conceptualized, as highlighted by Bucyibaruta(2018).

Applicability considerations are crucial when translating study findings to specific populations, interventions, or settings, as emphasized by Sekhon (2018). Unlike clinical trials, systematic evaluations of public health and health promotion interventions pose unique challenges in determining applicability. For instance, non-randomized designs may lack clear eligibility criteria, settings, and interventions, making applicability assessment more complex, as noted by Black (2018). Additionally, the presence of multiple intervention elements makes it difficult to identify the specific component responsible for observed effects and assess component interactions. Furthermore, assessing adoption and adherence in community programs can be challenging, hindering the comprehension and utilization of results. The diverse socio-cultural aspects of communities further complicate applicability determination. Nonetheless, this heterogeneity may enhance applicability by offering diverse populations, settings, and interventions, increasing the likelihood of broad applicability.

Functionality

While there is ongoing demand for objective measures in therapeutic contexts, recent discussions have challenged their sole reliance as outcome metrics Cieza& Stucki, 2018; MacDermid& Stratford, 2018). Jester, Harth, Wind (as cited in Girgis, 2020) posited that treatment effectiveness is now increasingly evaluated by monitoring functional outcomes that hold significance for the patient. Moreover, it has been suggested that functional status assessments are more discriminatory in gauging severity and are more accurate predictors of future disability compared to physical examinations or laboratory tests.

In clinical practice, patient-centered therapy prioritizes subjective measurements like questionnaires and functional outcome assessments to evaluate daily functioning and psychological well-being, especially in clinical physical therapy (Higginson &Carr, 2019). Jette (2019) described how occupational therapists, collaborating within a multidisciplinary team, can improve patient management by promoting effective communication among healthcare professionals, setting patient-centered goals, and planning recovery timelines, including return-to-work strategies, using functional outcome measures. MacDermid (2019) stressed the importance for clinicians to consider several characteristics when evaluating questionnaires. Key factors include establishing validity, responsiveness, and reliability of the instrument. These components indicate that the psychometric properties of the instrument have been assessed for a particular group and purpose, which holds significance for clinicians. Additionally, successful outcome measuring tools should demonstrate minimal burden on both clinicians and patients, alongside proven validity and reliability in a clinical setting.

Quick Dash

As per the Institute for Work and Health, the Disability of the Arm, Shoulder, and Hand (DASH) questionnaire, comprising 30 items, assesses physical function and symptoms in adults experiencing upper extremity musculoskeletal issues. Both the DASH User's Manual (2020) and Quick-DASH Outcome Measure Instruments have been developed. To enhance usability and decrease item redundancy, the QuickDASH, an 11-item questionnaire, was introduced. The Quick-DASH can be applied with equivalent accuracy as the DASH in various conditions such as Carpal Tunnel Syndrome, ganglion disorders, and shoulder ailments. Gummesson(in Herrero, 2017) compared the 11-item Quick-DASH to the 30-item DASH and found that Quick-DASH scores, derived from full-length DASH responses, can effectively replace DASH scores. The study suggests using the same questionnaire in longitudinal studies to prevent score variations from inflating small differences. Quick-DASH scores were slightly higher in every analysis, especially among patients with more disability, indicating potential accuracy in identifying varying disability levels. ROC curves showed no differences in the two measures' ability to identify improvement in arm status following surgery.

Leeuwen (as cited in Zwaan, 2022) investigated the utilization of the Quick-DASH in assessing upper extremity function after TR-PCI, but its applicability for TR-PCI-related issues in the upper extremity remains uncertain. This study aimed to establish the reliability of DASH and Quick-DASH questionnaires in evaluating upper extremity dysfunction (UED) following TR-PCI and to assess the interchangeability and validity of these patient-reported outcome measures (PROMs). The study hypothesized that patients undergoing TR-PCI without UED would report similar (Quick)DASH scores to those experiencing UED during the procedure.

In Budtz's study (2018), emphasis was placed on the importance of employing responsive, valid, and reliable outcome measures for assessing treatment effectiveness. The Disabilities of the Arm, Shoulder, and Hand questionnaire (DASH) provides versatility for evaluating upper extremity conditions, proving valuable for clinicians and researchers. The DASH, consisting of 30 items, assesses symptoms and physical functioning in patients with various musculoskeletal upper extremity issues. Cross-culturally adapted to Danish, it has demonstrated reliability, validity, and responsiveness across orthopedic patients with diverse hand and shoulder diagnoses. The Quick-DASH, a condensed version of the DASH questionnaire, comprises 11 items measuring difficulty in performing physical activities due to shoulder, arm, or hand problems (6 items), pain and tingling intensity (2 items), and the impact on social activities, work, and sleep (3 items). Both instruments utilize the same five DASH response options.

In Khan's study (2019), various assessment tools were utilized to evaluate upper limb impairment. The Disability of the Arm, Shoulder, and Hand (DASH) questionnaire, developed by the American Academy of Orthopedic Surgeons, serves as a specific outcome measure for upper extremity function assessment. Translated into multiple languages, it is widely employed in clinical trials and research focusing on upper extremity conditions. Additionally, the Quick-DASH, a condensed version of the DASH questionnaire, was used in the study to assess the long-term functional outcomes of replanted and revascularized upper limbs following corrective secondary surgeries.

Mintken(2018) emphasized the importance of responsiveness as a critical characteristic of assessment scales for evaluating treatment outcomes. Responsiveness includes the concept of Minimum Important Change (MIC), which represents the smallest score change that would be considered significant from the patient's perspective, indicating the questionnaire's ability to detect changes over time in the relevant domain. Additionally, the Minimum Detectable Change (MDC), representing the smallest change in score beyond measurement error, should ideally exceed the MIC to ensure that the MIC is distinguishable from measurement error.Terwee(2018) highlights that Quick-DASH responsiveness has been evaluated across various countries, populations, contexts, and outcomes. However, the responsiveness of the Danish version of Quick-DASH has not been assessed using either the anchor-based approach or a population of shoulder patients. The study emphasizes the importance of evaluating responsiveness in the specific context where the questionnaire will be used, as responsiveness and Minimum Important Change (MIC) are likely influenced by population and contextual variables.

Total Active Motion .

Libberecht (as cited in Spark, 2018) suggested categorizing range of motion (ROM) measures using the Total Active Motion (TAM) classification system established by the American Society for Surgery of the Hand (ASSH). Total active flexion (TAF) was determined by subtracting the total extension deficits observed at each joint (metacarpophalangeal joint [MCPJ], proximal interphalangeal joint [PIPJ], and distal interphalangeal joint [DIPJ]) from the total degrees of flexion at each joint (MCPJ, PIPJ, DIPJ). Johnson (2018) proposed using the Total Active Motion (TAM) method to evaluate functional outcomes in burned hands, wherein the patient simultaneously flexes the distal interphalangeal (DIP), proximal interphalangeal (PIP), and metatarsophalangeal (MCP) joints. A single sum represents the complete active flexion of the digit, with measurements taken with all joints fully extended. Any shortfall in extension is subtracted from the total active flexion to calculate the TAM. This approach yields one functional measurement per finger suitable for assessing burned hands, particularly valuable for monitoring scar tissue development and comparing results between patients or different treatment techniques.

Calhoun (2021) further explains the concept of Total Active Motion (TAM) as Active Flexion minus any Extension Deficits. It involves adding up all flexion degrees and subtracting extension deficits. For instance, if the MP joint has 90 degrees of flexion, the PIP lacks 10 degrees of extension with 85 degrees of flexion, and the DIP lacks five degrees of extension with 55 degrees of flexion, the total TAM is calculated accordingly. While this method is commonly used, it may not be precise if there is hyperextension. Similar calculations apply to total passive motion. Alternatively, for composite finger motion, simply measure from the tip to the distal palmar crease, providing a quicker and simpler measurement approach.

Collocott(2020) conducted a randomized clinical trial comparing two Early Active Mobilization (EAM) programs: Relative Motion Extension (RME) and Controlled Active Motion (CAM), each using different orthoses. The study found that the RME program resulted in earlier functional hand use, Total Active Motion (TAM), and higher satisfaction scores compared to the CAM program. Both EAM programs were deemed safe, with no tendon ruptures reported, and early Return to Work (RTW) was possible according to corporate policy. Participants in the RME program, utilizing RME finger orthosis, exhibited significantly better early hand function, TAM, and orthosis satisfaction than those in the

CAM program using a static wrist-hand-finger orthosis. This superiority is attributed to the less constrictive design of the RME orthosis. Consequently, the RME program supports a safer and quicker return of hand function and motion following restoration of zones V and VI extensor tendons compared to a CAM regimen. In the research done by Wille(2020),patients undergoing flexor tendon repairs who engaged in early active flexion exercises using forearm-based Dynamic Brace Systems (DBS) within 3 to 5 days post-surgery demonstrated significantly better total active motion at 4 weeks compared to those following an early passive motion protocol involving passive mobilization and place and hold exercises for the first 3 weeks, with active motion starting around 22 days post-surgery. However, no notable differences in total active motion were observed between the two groups at 12 weeks post-surgery. Patients fitted with a Manchester short splint after zone II flexor tendon repairs exhibited a significantly larger total arc of flexion and less extension deficit at the proximal interphalangeal (PIP) and distal interphalangeal (DIP) joints at 6 weeks compared to those fitted with a forearm-based DBS. At 12 weeks, those fitted with a Manchester short splint showed a significantly lower PIP joint extension deficit than those with a forearm-based DBS, although there was no significant difference in the DIP joint extension deficits between the two groups.

Assessment post-Extensor Tendon Repair

In Kadah's study (2020), the term "total active motion" (TAM) denotes the entire range of motion of individual digits. Miller's classification, which is based on TAM, was employed to evaluate the outcomes of acute extensor tendon repairs. This measurement can be compared to the TAM of the opposite finger or to the norm of 260 degrees. Merrit (as cited in Newington, 2021) highlighted that while grip and pinch strength are commonly used measures of hand function, they do not specifically assess extensor function. However, dynamometer measurements remain valuable for evaluating overall hand function. Both the American Society for Hand Surgery and The American Society for Hand Therapists recommend using the JAMAR dynamometer to assess grip strength due to its accuracy and reliability. It is advisable to compare readings with the unaffected hand when possible. Additionally, Miller's criteria have demonstrated that the ICAM splint program yields "excellent" to "good" outcomes in the US setting.

The assessment of tendon repair outcomes has been approached through various methods. One such method, proposed by the American Society of Hand Surgery, involves evaluating active flexion at the metacarpophalangeal (MP), proximal interphalangeal (PIP), and distal interphalangeal (DIP) joints, along with assessing the reduction in extension loss for each joint compared to the healthy finger. Additionally, Buck-Gramko (as cited in Ishak, 2019) measured the distance from the pulp to the palmar, total active motion (TAM), and active extension loss of the finger. However, this assessment method can be time-consuming and challenging to replicate during each patient consultation. Johnson and Tubiana(2020) proposed an evaluation method focusing on the motion of the proximal interphalangeal (PIP) joint. This technique precisely determines the loss of active extension and active flexion of the finger by assessing the position of the second phalanx relative to the metacarpal position. Unlike measuring the arc of movement, this method evaluates the overall functionality of the finger. However, Strickland (2018) described a simpler approach that measured the total active motion (TAM) of the PIP and distal interphalangeal (DIP) joints, without considering movement across the metacarpophalangeal (MP) joint. Additionally, Giffen (2020) combined TAM calculations for three digits (middle, ring, and little) to generate an overall figure. However, this combined TAM approach complicates comparisons with other trials and

analysis of individual joint results. The varied interpretations of TAM across studies highlight inconsistencies and challenges in its application.

METHODOLOGY

To obtain the necessary data needed for the study, followed a descriptive-developmental design, specifically a cross-sectional method Creswell & Creswell, 2019 According to McCombes (2019), Descriptive developmental designs refer to when data are collected. These included cross-sectional, longitudinal, and sequential designs. Through this research design, this study evaluates the relative motion splint in management of extensor tendon repair of Zone 5-7. Likewise, a cross-sectional study is a type of observational research design that analyzes data collected at one specific point in time from a population or a representative subset of that population. In the context of evaluating the relative motion splint in the management of extensor tendon repair of Zone 5-7, a cross-sectional study would involve assessing a group of patients who have undergone this treatment at a particular moment in time. Researchers would gather data on factors such as patient demographics, the severity of the injury, the effectiveness of the splint in promoting healing and restoring function, and patient satisfaction with the treatment. By conducting a cross-sectional study, researchers can obtain valuable insights into how well the relative motion splint works in real-world clinical settings, identify any challenges or limitations associated with its use, and assess its overall acceptability among patients and healthcare providers. This type of study can provide valuable information for improving the management of extensor tendon repairs in Zone 5-7 and guiding future research and clinical practice in this area.

The respondents of the study were (10) Occupational Hand Therapists from Qatar. The sampling technique that was employed in this study was purposive sampling and stratified sampling since criteria was set to choose the respondents that was included in this study. The questionnaire was created by the researcher, and was validated by three experts: a researcher, statistician, and a professor who were having at least Masteral studies and expert in the field. They have examined the questionnaire and gave suggestions. Furthermore, the study's reliability was contingent on the statistician's ability to comprehend the adequacy of the scale in order to determine whether the expected result will be applied to a statistical formula once the data are gathered. Prior to the release of the questionnaire, their ideas and criticisms were adopted

The weighted mean was used to evaluate the relative motion splint in management of extensor tendon repair of Zone 5-7.

RESULTS

Table 1
The Level of Acceptability of the Management of extensor tendon of Zone 5-7 in management of Extensor Tendon repair of Zone 5-7 in terms of its applicability

Indicator **Applicability**	Weighted Mean	Verbal responses
1. In terms of fabrication is it RME/ICAM splint is easier to fabricate in comparison to	4.0	Very High

Early Controlled Mobilization Splint		
2. RME/ICAM splint is easy to use in comparison to early controlled mobilization	4.0	Very High
Average	**4.0**	**Very High**

It is depicted in Table 1: The Level of Acceptability of the Management of the extensor tendon of Zone 5-7 in the management of extensor tendon repair of Zone 5-7 in terms of its applicability. Indicator 2" RME/ICAM splint is easy to use in comparison to early controlled mobilization was interpreted as Very High with a weighted mean of 4.0 was ranked 1 and Indicator 1 "In terms of fabrication is it RME/ICAM splint is easier to fabricate in comparison to Early Controlled Mobilization Splint was interpreted Very High with a weighted mean of 4.0 and was ranked 2.

Table 2
The Level of Acceptability of the Management of extensor tendon of Zone 5-7 in management of Extensor Tendon repair of Zone 5-7 in terms of its Functionality

Indicator **Functionality**	Weighted Mean	Verbal Interpretation
1. The patient can use their hand while performing light activities while wearing ICAM splint. (less than 500 grams eg, grooming, dressing and using cutlery etc)	4.0	Very High
2. The ICAM splint will allow the usage of the hand in heavy activities (more than 500grams, eg carrying shopping, using hammer and drilling machine)	2.9	High
Average	3.85	Very High

Table 2: reveals that the level of acceptability of the management of extensor tendon of zone 5-7 in management of extensor tendon repair of Zone 5-7 in terms of its functionality, Indicator 1 "The patient can use their hand while performing light activities while wearing ICAM splint. (less than 500 grams eg, grooming, dressing and using cutlery etc) was interpreted as Very High with a weighted mean of 4.0 was ranked 1 and Indicator 2 "The ICAM splint will allow the usage of the hand in heavy activities (more than 500grams, eg carrying shopping, using hammer and drilling machine" was interpreted as Agreed with a weighted mean of 2.9 was ranked 2.

Table 3`
The Level of Acceptability of the Management of extensor tendon of Zone 5-7 in management of Extensor Tendon repair of Zone 5-7 in terms of Range of Motion

Indicator **Range of motion**	Weighted Mean	Verbal Interpretation
1. ICAM Splint can achieve a good total active motion (TAM) on affected digits compared to Early controlled mobilization.	4.0	Very High
2. ICAM splint provide a better outcome in terms of recovery of hand function	4.0	Very High
Average	4.0	Very High

As shown in Table 3 the level of acceptability of the management of extensor tendon of Zone 5-7 in terms of range of motion Indicator 2" ICAM splint provide a better outcome in terms of recovery of hand function was interpreted as Strongly Agreed with a weighted mean of 4.0 was ranked 1 and Indicator 1" ICAM Splint can achieve a good total active motion (TAM) on affected digits compared to Early controlled mobilization was interpreted Strongly Agreed with a weighted mean of 4.0 was ranked 2.

Enhancement to Improve the Relative Motion Splint

There is a need to implement the enhancement to improve the relative Motion Splint in Management of Extensor Tendon on Zone 5-7 using Intermediate Controlled Mobilization ,to enhance the relative motion splint for managing extensor tendon repair in Zone 5-7 using Intermediate Controlled Mobilization (ICAM), key considerations include refining the splint design for comfort and functionality, providing thorough training to therapists and patients, ongoing monitoring of outcomes, and fostering collaboration between stakeholders for continuous improvement.

DISCUSSION

In Table 1: This means that the level of acceptability of the management of the extensor tendon of Zone 5-7 in management of extensor tendon repair of Zone 5-7 in terms of its applicability has a very high level in terms of applicability mean (4.00). It further implies the participant's acceptability regarding RME/ICAM splint was easy to use and fabricate in comparison to early controlled mobilization.

In Table 2: This means that the level of acceptability of the management of the extensor tendon of Zone 5-7 in terms of its functionality has a very high level in terms of functionality mean (3.85). This suggest that the patient can use their hand while performing light activities while wearing ICAM splint. (less than 500 grams eg, grooming, dressing and using cutlery etc and The ICAM splint will allow the usage of the hand in heavy activities (more than 500grams, eg carrying shopping, using hammer and drilling machine).

In Table 3: This means that the level of acceptability of the management of the extensor tendon of Zone 5-7 in terms of its Range of Motion was very high level in terms of Range of Motion mean (4.0). It further implies that ICAM splint can achieve a good total active motion (TAM) on affected digits compared to early controlled mobilization.

4. Enhancement to Improve the Relative Motion Splint

Enhancing the relative motion splint for managing extensor tendon repair in Zone 5-7 using Intermediate Controlled Mobilization (ICAM) requires careful consideration and attention to various key factors:

1. Refining splint design for comfort and functionality: The splint design plays a crucial role in patient compliance and comfort during the rehabilitation process. By refining the design to prioritize comfort and functionality, patients are more likely to adhere to the prescribed protocol, leading to better outcomes.
2. Providing thorough training to therapists and patients: Proper training is essential for both therapists and patients to ensure the effective implementation of the ICAM protocol. Therapists need comprehensive training to accurately assess patients' needs, adjust the splint as necessary, and guide patients through the rehabilitation process. Similarly, patients require thorough training to understand the purpose of the splint, how to use it correctly, and what to expect during their recovery journey.
3. Ongoing monitoring of outcomes: Continuous monitoring of patient outcomes is crucial for evaluating the effectiveness of the ICAM protocol and identifying areas for improvement. Regular assessments allow therapists to track patients' progress, identify any issues or challenges early on, and make necessary adjustments to optimize outcomes.
4. Fostering collaboration between stakeholders for continuous improvement: Collaboration among various stakeholders, including therapists, patients, surgeons, and researchers, is essential for driving continuous improvement in the management of extensor tendon repair. By fostering open communication and collaboration, stakeholders can share insights, exchange best practices, and work together to refine the ICAM protocol and enhance patient care.

CONCLUSIONS

The respondents manifest a high level of acceptability of the management of the extensor tendon of Zone 5-7 in terms of its applicability. They perceive the RME/ICAM splint as easier to utilize and construct, suggesting its potential as a favored approach for addressing extensor tendon repair in Zone 5-7.

Moreover, the respondents exhibited a very high level of acceptability of the management of the extensor tendon of Zone 5-7 in terms of its functionality. This implies that patients can engage in light activities while wearing the ICAM splint (weighing less than 500 grams), such as grooming, dressing, and using cutlery. Additionally, the ICAM splint enables hand usage in heavy activities (exceeding 500 grams), such as carrying shopping, using a hammer, and operating a drilling machine.

Furthermore, the respondents demonstrated a high level of acceptability regarding the management of the extensor tendon of Zone 5-7 concerning its range of motion. This suggests that the ICAM splint can attain a satisfactory total active motion (TAM) in affected digits compared to early controlled mobilization. Consequently, there is a need to implement enhancements to improve the relative Motion Splint in Management of Extensor Tendon on Zone 5-7 using Intermediate Controlled Mobilization. To enhance the relative motion splint for managing extensor tendon repair in Zone 5-7 using Intermediate Controlled Mobilization (ICAM), key considerations include refining the splint design for comfort and functionality, providing thorough training to therapists and patients, ongoing monitoring of outcomes, and fostering collaboration between stakeholders for continuous improvement.

Based on the findings and conclusions, several recommendations emerge. Firstly, considering the high level of acceptability observed among respondents regarding the applicability of the RME/ICAM splint for managing extensor tendon repair in Zone 5-7, it is advisable to further promote and integrate this approach into clinical practice. Healthcare facilities and rehabilitation centers should prioritize providing training and resources to therapists and clinicians on the proper utilization and fabrication of the RME/ICAM splint.

Additionally, ongoing research and collaboration among healthcare professionals can refine and optimize the effectiveness of this approach, ultimately improving patient outcomes. Occupational therapists should educate patients on the appropriate use of the ICAM splint for both light and heavy activities, emphasizing its potential to facilitate hand function across various tasks. Ongoing monitoring and support from occupational therapists or hand specialists can ensure proper utilization of the splint and optimize patient outcomes. Hand therapists should incorporate the ICAM splint into rehabilitation protocols for patients undergoing extensor tendon repair in Zone 5-7, highlighting its effectiveness in promoting optimal range of motion outcomes. Collaboration between occupational therapists and hand therapists is crucial to refine splint design, provide comprehensive training, monitor outcomes, and continuously improve patient care.

Furthermore, future research should explore the long-term effectiveness and patient satisfaction of the relative motion splint in managing extensor tendon repair in Zone 5-7 using Intermediate Controlled Mobilization (ICAM). Investigating the impact of different rehabilitation protocols and patient-specific factors on treatment outcomes would also be valuable.

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