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Research Article

A Rapid Brostrum Rehabilitation Protocol Using Improved Fiberwire Technique

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Abstract

Ankle reconstruction patients represent a common patient group in both private practice physiotherapy and specialist foot and ankle practices. Building on our extensive experience with this procedure we have posed the question "how can the rehabilitation of these patients be accelerated?". We have for 20 years used the same protocol originated by Dr Marty O'Malley at The Hospital for Special Surgery (Slater., *et al.* 2011, World J. Ortho 2, 31-36). Based on our experience we have modified the surgical methodology and here report on an accelerated protocol, the Rapid Brostrum Rehabilitation Protocol (RPRB). The protocol allows for immediate weight bearing with no plaster and reduced reliance on a post-operative boot. With this, return to function has been halved and there has been a faster recovery. There has however been an increase in the reoperation rate in certain cases indicating that cautions is required in some concomitant pathologies.

We propose that the RBRP protocol is a valid and improved method to address this problem allowing for a more rapid return to sporting activities.

Keywords: *Brostrom; Lateral Ligament Reconstruction; Medial Ligament Reconstruction; Anchor*

Abbreviation

BLHR: Bilateral Limb Heel Raise; CAM: Controlled Ankle Motion; cm: Centimeter; DVT: Deep Vein Thrombosis; FWB: Full Weight Bearing; KTW: Knee to Wall; MCL: Medial Collateral Ligament; mm: Millimeter; N: Newtons; NWB: Non-weight Bearing; ROM: Range of Motion; RPRB: Rapid Brostrum Rehabilitation Protocol; SLHR: Single Limb Heel Raise

Introduction

Ankle injury is the most common sporting injury with lateral ligament sprains the most common injury to occur at the ankle [1-3]. The prevalence of ankle instability is high in the general population [4]. For example, in one study subjects self-reported 23% bilateral and 8% unilateral incidence of ankle instability [5]. Non-operative conservative management is usually trialled first and is successful for 80 - 85% of acute ankle sprains [6]. The remaining 15 - 20% have recurrent ankle instability leading to re-injury and often go on to receive surgical intervention [6]. However, if not rehabilitated properly the proportion requiring surgery can rapidly increase. Poorly rehabilitated ankles can result in chronic pain, muscular weakness, and recurrent instability has been shown to be prevalent in as many as 70% of athletes [7,8]. Persistent symptoms may include feeling of giving way or true mechanical instability when tested with anterior drawer or talar tilt [6]. Ongoing ankle ligament laxity on testing is associated with persistent deficits in explosive power, agility and proprioception which can detrimentally impact athletes, impairing ability to reach higher levels of sports and increase risk of ankle re-injury [9,10]. Our observation was patients with medial collateral ligament (MCL) injuries were common and some authors purport that there is a significant number where the MCL injury contributes to the ankle instability [10,11]. Failure to repair the MCL would in turn lead to an increased recovery time and return to sporting activities.

The surgical standard for repair of ankle instability is the Brostrom ligament reconstruction technique [2,6,12]. This technique repairs the damaged lateral and sometimes medial ligaments with a strong suture to return stability to the ankle. Studies of modified Brostrom techniques have favourable results. Comparing other surgical ankle reconstruction procedures with Brostrom technique the modified Brostrom group had the least amount of anterior talar displacement and talar tilt angle at all forces therefore producing greater mechanical restraint [13]. Research previously has shown return to pre-injury function from high-demand athletes following modified Brostrom procedures [13]. More than 80% of patients had good outcomes post operation and less complications compared to Chrisman-Snook reconstructions [12]. We are also aware of the number of failures in Brostrom reconstructions and although have not found to be a problem in our previous series decided that logically to accelerate recovery that the procedure needed to be stronger than current techniques being performed [2,6,14].

We report on our initial experience with 110 ankle reconstructions and propose that the accelerated recovery of patients does align with our proposed technique.

Methods

We approached Integrant (Sydney, Australia) to produce an anchor that had a 3.5 mm titanium corkscrew with a coarse thread producing maximum interference fit into the fibula. The anchor had a pull out strength over 3500N. The problem with most anchors we have used was that the thread size and needle strength diminishes with the anchor size producing a weak link in the repair. To counteract this needles were manufactured that were larger, sharper and stronger (Figure 1). These needles were attached to fibre wires with 4 fibre wires per anchor.

2 sutures per anchor were made. The theory was a sharp stronger needle could be passed further without breaking or distorting compared to smaller needles on the market (Figure 1). This would in turn lead to a stronger repair.

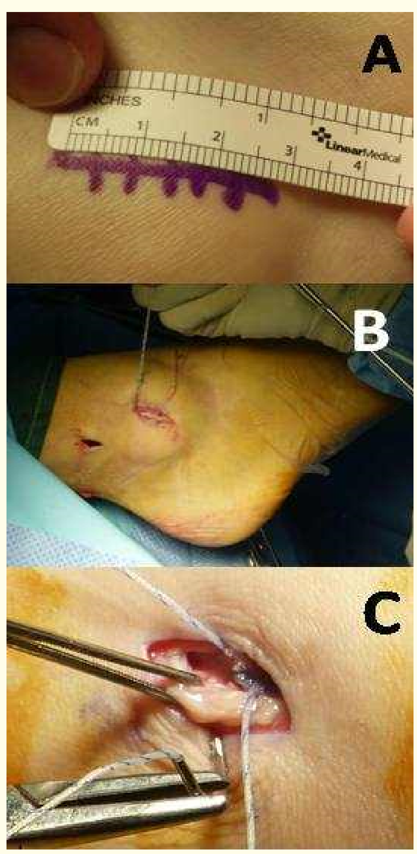

Figure 1: *Surgical Repair of Lateral Ligament. A. Minimally invasive incision over the lateral ligament complex. B. Foot elevated using anchor thread demonstrating strength of screw implantation. C. Larger needle size enhances technique, enabling faster and stronger sutures.*

To further produce a margin of safety patients who had MRI findings of a MCL tear combined with a positive medial draw test and pain underwent simultaneous MCL repair. This was performed through a medially placed 3 cm incision exposing the MCL and repairing the MCL with two anchors. The ligament was explored and divided with a linear incision. Two Anchors were placed in the medial malleolus and imbrication performed side to side and advancement performed. Fluoroscan was used to check the position of the anchors. The deeper anchor was targeted to the deep distal elements of the ligament whilst the more proximal was placed into the superficial components of the deltoid.

An incision was made of 3 cm in length over the anterior border of the fibula. The anterior capsule of the ankle joint was exposed and divided. Two anchors were inserted. One at the distal tip along the longitudinal axes of the fibula. The other corresponding to a point 5 mm inferior from the trifurcation point and at a 90 degree angle to the fibula.

Fluoroscopy was used to confirm the position of the anchors. Care was taken to not over-drill the anchors with bone density judged by the initial reamer resistance. The anchors were inserted and tested for pull out strength. The fit is such that the entire leg can be lifted from a single anchor.

As the needles are larger often a needle was removed after initial insertion to aid removal of the remaining needle from the inserter. As the needles are larger this makes removal of the inserter easier. The amount of fiber wire needed is judged to limit the possibility of the threads becoming entangled.

The fiber wire is inserted beginning with the distal anchor. The first thread is passed through the capsule in the ATFL zone in an inside to out and then outside to in fashion. It is clipped to the end of the fiber wire that had its needle removed and clipped with an artery. Traction on this suture then allows the more distal capsule to be delivered into the surgical field hence decreasing the size of the incision required.

This process is repeated at the proximal part of the field. Extensor retinaculum is included in this portion of the incision aiding the strength of the repair. Care is taken to avoid the superficial peroneal nerve. The sutures are then tied off in sequence as firmly as possible by hand beginning with the distal sutures. The ankle is placed in eversion.

The remaining cuff of tissue at the Fibula is then advanced using all but the proximal suture. This evolved in the technique as there was less material to cover the knot of the fiber wire here.

An incision is made over the tip of the medial malleolus. Two anchors are placed one for the deep fibers and another for the more superficial elements. Due to the nature of the medial collateral ligament one suture was used from each of the anchors.

Of note peroneal tendon injury patients were excluded as were high sprain patients and patients with varus heal requiring a calcaneal osteotomy. Revision patients were not excluded. Patients with osteochondral lesion were included. In this series there were no patients that had an osteochondral lesion greater than 10 mm. Osteochondral lesions underwent chondroplasty back to a stable base. Aggressive stimulation of the base was not employed in favour of a light stimulation of the bone surface with a chondrotome blade.

Local anaesthetic was infiltrated(need dose diluted to 40 ml with normal saline.) Incision was closed using three o vicryl and interrupted three 0 nylon.

Post-op a compression bandage was placed. In recovery if there was no bleeding at the incision site for 2 hrs a controlled ankle motion (CAM) boot with inflatable liner was inserted. The patient was then encouraged to weight bear in recovery.

Post-op the boot was removed if the patient was comfortable at the two week mark. Roughly a quarter of the patients were able to achieve this. A further 50% able to achieve this at 4 weeks and all but a small percentage were able to do this at 6 weeks (Number = 10). The patient was given our standard rehabilitation protocol and sent to physiotherapy rehabilitation as outlined below. Rehabilitation programs lasted between 10 - 14 weeks with patients encouraged to progress between stages based on achieving objective milestones rather than being constrained by times.

Results

Study Population

There were 110 patients (Figure 2). 40 had medial and lateral whilst 70 were lateral only. All returned to stability and had resolution of pain similar to our previous study [14]. All were immediate weight bearing in a CAM boot. All were day case.

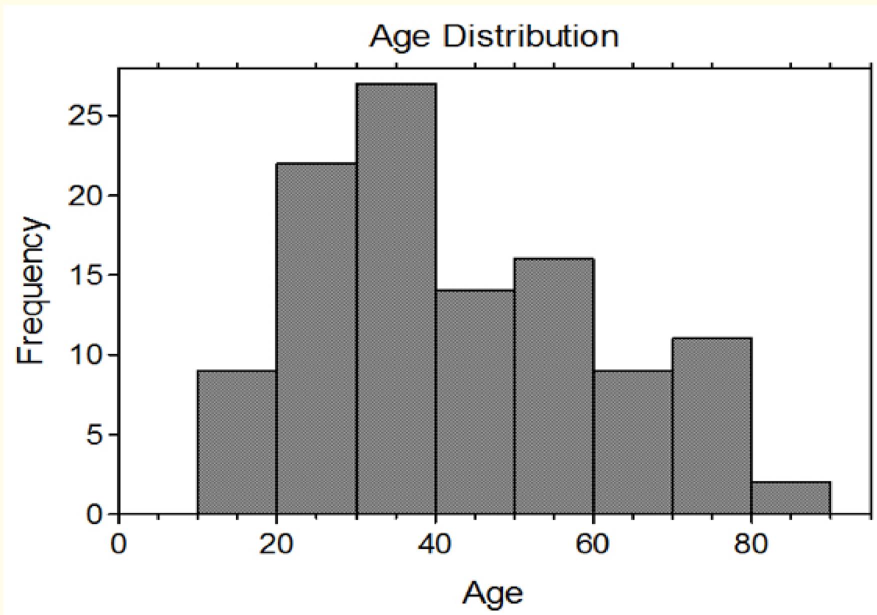

Figure 2: *Patient demographics for the study.*

Complications

6 patients required anchor removal. two for medial sided anchor impingement issues. 2 lateral removal. one for infection in a revision patient and one for misplacement which would appear to be a parallax error in placement on x-ray.

Infection of the incision occurred in 5 patients. This was generally superficial and responded to oral antibiotics. But there were two cases where a resistant bacteria (*Staphylococcus aureus* resistant to flucloxacillin but sensitive to Clindamycin)was encountered which required the anchor to be removed. This was in a revision case. Patient was a smoker.

The other patient was diabetic with a community acquired *Staphylococcus aureus* sensitive to flucloxacillin. This did not resolve with antibiotics and it was elected to remove the anchors at 4 months.

There were two superficial deep vein thrombosis (DVT) which were symptomatic. Routine DVT screening was not employed. Prophylaxis is given when there is a past history of DVT. Otherwise immediate weight bearing is used and movement encouraged.

Saphenous nerve was caught in one patient. This needed to be explored and released of a suture. The nerve was then wrapped in local fibrous tissue. Pain still settled slowly with a course of Lyrica (pregabalin). 150 mg nocte.

Note that stability was maintained in all patients. It would appear that if infection does occur that there irritation produces considerable scar tissue which aids the return of stability.

Even though infection rates were similar to our previous study (Slater., et al.) the rate of more serious complications which require removal of the implant was higher. This was perhaps not unsurprising as the fiber wire is an implant. If infection does occur it can contaminate the implant and then basic surgical principles of dealing with infected implants apply. Response to infection was removal of the fiber wire in the infected zone.

There is also an increase in the amount of resistant organisms in society. This has ramifications to the use of prophylactic antibiotics and also the type of antibiotics that should be used to treat infection.

Rehabilitation

Early weight bearing and mobilisation following Brostrom reconstructive surgery enables acceleration through physiotherapy rehabilitation and quicker return to sport than other ankle reconstructions that require periods of immobilisation [15,16]. Patients following Brostrom reconstructive surgery will move through each aspect of strength, mobility and control as able and determined by achievement of specific objective milestones rather than time based progressions. Following this accelerated protocol patients have been able to return to light running treadmill as early as 4 - 8 weeks post-operatively (Table 1). With most rehabilitation programs lasting between 10-14 weeks. This is a significant improvement over the previous rehabilitation program and leads to cost savings in labor and greater patient satisfaction anecdotally.

Phase	Focus	Phase Milestones	Accelerated (weeks)	Traditional (weeks)
1	Progress to full weight bearing (FWB) in boot Active plantarflexion/dorsiflexion as tolerated Isometric strengthening all directions		1 - 4	4 - 8
2	Restore full range plantarflexion/dorsiflexion - begin stationary cycling Resisted non-weight bearing (NWB) plantarflexion /dorsiflexion Balance/proprioception Isometrics inversion/eversion Progress to FWB without boot	Achieve full range R=L plantarflexion/dorsiflexion or KTW 10 cm 40 degrees gastrocnemius muscle length assessed in standing Restore normal gait pattern	2 - 6	8 - 12
3	Commence heel raises Inversion/eversion strengthening against resistance NWB Address other biomechanical factors - e.g. hip and knee strength/control	25+ x SLHR + 15 x BLHR 60 seconds eyes open single leg balance. 15 seconds eyes closed single leg balance	4 - 8	12 - 20
4	Hop and land Straight line running	Triple hop for distance, 6 meter timed hop, single leg hop and triple crossover hop within 90% of opposing limb	6 - 12	12 - 20
5	Commence direction change running, agility, non-contact drills, functional training		8 - 16	20 - 28
6	Return to sport		12 - 20	28+

Table 1: *Accelerated versus traditional rehabilitation protocol.*

Discussion

Physiotherapy intervention commences immediately post operatively following initial recovery from surgery and wound healing. The three main areas that physiotherapy intervention targets include mobility, strength and control of the ankle. Each section happens in parallel and speed of progression is determined individually by achievement of specific objective milestones (Table 1).

Mobility

Early weight bearing made possible by a stronger ligament repair enables maintenance of ankle range and return to normal gait patterning faster than compared to immobilisation regimes following surgically repaired ankle fractures [1,16,17]. It also appears to be more effective than immobilisation following ankle ligament sprain without surgery [18]. Early weight bearing has shown favourable outcomes for returning to full function following other trials of modified Brostrom [15].

Previous studies following Brostrom have had protected weight bearing ranges for the initial 3 weeks of only 0-20 degrees plantar flexion and 0-10 degrees dorsiflexion, with a gradual progression over 6 weeks to full ROM. Inversion ROM added last [15]. However, these time frames were only used as a guideline and it may appear that returning to full ROM can be accelerated further based on individual recovery speed. Non-weight bearing active mobility practice can be started immediately post op and progressed to weight bearing mobility activities such as lunges and stationary cycling as pain and swelling allows.

The aim initially post operatively is to restore ankle plantar flexion and dorsiflexion to equal to the opposite side or to a 'standard' acceptable range (10 cm KTW/40 degrees gastrocnemius muscle length assessed in standing). Specific manual therapy performed by physiotherapist targeting talocrural, mid foot and subtalar joint mobility can assist return to full range.

Strength

The aim of strength training is to maintain/regain calf muscle strength/bulk. Strength training can be commenced immediately with resisted non-weight bearing plantarflexion and dorsiflexion. Strengthening into plantar flexion plus inversion is safe to commence at 6 weeks postoperatively based on previous studies [15] but can be initiated sooner if patient progressions allow. Weight bearing progressions include double leg heel raises to single leg. Once patient can perform single leg heel raises x 25 well controlled repetitions with straight leg and x 15 well controlled repetitions with bent knee they can commence hopping and landing practice [19]. Hopping and landing drills precede return to running and change direction sports.

Strength training may also target other lower limb area's that may have contributed to initial injury or may contribute to a successful return to sport. These are targeted based on individual physiotherapists assessment.

Control

Regaining proprioceptive joint control is crucial following ankle reconstruction surgery and decreased inversion proprioceptive control has been associated with increased risk of ankle injury [9,20]. Balance training is an effective treatment for reducing risk of reinjury [21]. Single leg balance is commenced and progressed as pain and swelling allow. When patient can achieve single leg balance 60 seconds eyes open and 15 seconds eyes closed they can progress to more complex stability training [22].

Complications

Progressing through rehabilitation can be limited by pain, persistent swelling, joint synovitis or infection

Return to function and sport

Return to function and sport depends on achieving milestones mentioned above in each aspect of strength, mobility and control. The patient then completes a series of return to function testing that may include triple hop for distance, 6 meter timed hop, single leg hop and triple crossover hop [23,24]. Results should be at least 90% of opposing limb before return to functional training can commence [23].

Conclusion

The Brostrom procedure since its inception has been an enormously successful procedure. The new paradigm is how fast can the rehabilitation program go without a statistical unsatisfactory increase in the complication rate. This is paramount in patients that are self-employed and the professional athlete.

In order to rehabilitate quickly the surgeon needs to recognise the degree of ligament damage and repair this. In particular attention to the MCL. The literature has identified that not recognising laxity at the medial ligament may lead to failure of the procedure [10,11].

Patients who are at risk of slow healing in our series such as smokers, diabetics, chronic pain patients should be monitored closely and not involved in the Rapid Rostrum Rehabilitation Protocol (RBRP).

There have been disappointing results in artificial ligament procedures in the past. We believe that if there is complete replacement of the ligament then there is a recognition of the loss of natural architecture, according to the basic laws of biologic mechanics. That is not unlike Newtons Third Law of equal and opposite recognition seen in stress shielding when it comes to hip replacement. When it comes to ligament technology the ligament needs to be replaced within the body in terms of the natural mechanical dependencies and then further be incorporated into the body. An example of the effects of stress shielding in the foot is the formation of cysts after ankle arthroplasty [25]. If natural mechanical forces are not restored there will be failure of the ligament due to fatigue.

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Conflict of Interest

Dr Slater designed the Anchor for Integrant as a consultant. Robert McPherson is an employee of a distributor for Integrant products. This study received no financial assistance.

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