

Review Article

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Post-Operative Recovery and Preparation for Ambulation after Foot and Ankle Surgery

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ABSTRACT

This is a review article that focuses on patient self-recovery, pain modulation without pain medication, edema control and preparation for ambulation after a foot or ankle surgery both elective and traumatic surgical procedures. The available evidence and literature review were limited due to the few studies that are devoted to this area of focus. This review article takes a comprehensive and prescriptive perspective into strategies of the aftermath of the physiological and psychological effects on the body, specifically the lower extremity after foot or ankle surgery. Some of these strategies include initial edema control, nutrition, scar massage and reduction of non-mobile skin from the surgical incision within the surgery. A review of the theory of prehabilitation and examples of therapeutic exercises are explained within the article which target important proximal gait muscles needed for ambulation which can be conditioned with the foot and ankle in a CAM boot or a cast.

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The post-operative time after foot and ankle surgery is critical as healing starts to occur at the area that was surgically fixated or repaired. Regardless of the type of surgery; ankle, metatarsal, calcaneal, Lisfranc fracture surgery, Achilles tendon, ATFL, peroneal tendon repair or Osteochondritis dissecans (OCD) repair; It is important the patients are educated on how to take care of their foot/ankle during the healing process. Icing and elevating your foot/ankle and lower leg every day (3-4 time per day during the first 7-14 days post-operatively) is a good practice to reduce the effects of inflammation. Inflammation produces edema which accumulates in the foot and ankle region status-post surgery and remains there for as long as up to a year, sometimes longer.

Cells such as cytokines are released into the blood stream and travel to the surgical site to aid development of endochondral healing of the bone and ossification. Osteosynthesis is the process of using hardware such as plates, screws and wires to surgically correct and promote the healing, closure and remodeling of the cortexes of the broken bone is essential to avoid delayed union, malunion and non-union from occurring (i.e. when the fracture pieces of the broken bone do not come together and coalesce as well as the fracture lines remain prominent despite the hardware fixation) [1-5]. This process can take up to 9-12 weeks or longer depending on the quality of bone. Pain will undoubtedly be accompanied with the physiological process of healing. Pain will mostly come from the excess edema that will localize around the surgical site. The edema is excessive swelling that will encapsulate the ankle, foot, or toes. It is a space occupying, free floating accumulation of liquid. Since these areas of the bodies (foot and ankle) are almost up against the skin, the increased pressure around the bones and subcutaneous tissues doubles which as a result will increase pain in the area especially on nerves around the foot and ankle [1,2,5,6]. This is why it is essential that the foot/ ankle and lower extremity is elevated on 5-6 pillows or a stack of 8-10 bedsheets

Cryotherapy (i.e. ice pack, ice massage, ice machine, contrast baths) is a way to help alleviate the pain after surgery. Using the RICE (Rest, Ice, Compression, and Elevation) principle every day post-operatively, is an effective way to help control the pain and discomfort from the inflammatory process from the surgery. The ice will cool down the increased skin and tissue temperature which is accompanied by the edema in the inflammatory response [7]. In some cases, depending on the level of trauma and type of surgery performed, the surgeon may place the ankle or foot in a hard cast. In this situation, the surgeon may put a rubber attachment with hoses protruding from the cast that is put on the patient in the operating room so that the patient can simply attach the hoses to the ice machine and facilitate ice cold water through the surgical area to aid in controlling edema and inflammation [7]. If this is not done, then the patient will need to wait until the cast is removed and the ankle/foot is placed in a CAM boot, before doing any self-icing such as ice massage or contrast baths. Ice packs may be placed over the cast, but compression with an ACE wrap will need to be applied to get the cooling effect.

**Ice Machine Figure**

The immediate time post operatively is the most critical in that no increased external or internal (i.e. bodyweight) pressure should be allowed to be attenuated through the surgical fixation or repair site. Increased pressure such as body weight during an attempt to walk on the post-surgical ankle foot (i.e.; get off the couch/bed and walk to the bathroom or get something from another room) is contraindicated. Weightbearing will vary depending on the type of surgery (i.e.... forefoot vs. rearfoot) as well as the type of hardware that is used. For forefoot surgery, bunions, hammer toes, toe arthroplasty, partial weightbearing can be started in 7-10 days. Rearfoot surgery; ankle, calcaneal, Achilles tendon repair, partial weightbearing can take a longer. In traumatic rearfoot surgery, it is vitally important NOT to fully weight-bear for at least 2 months after surgery. Even as little as 10 minutes of weightbearing can disrupt the tissues during the healing process, shift or break the surgical hardware in the ankle or foot, or increase the chance of a non or malunion of the bones that were surgically fixated from the repair. In a soft tissue repair, such as an Achilles tendon or peroneal tendon repair, weightbearing can rupture the sutures that made the repair.

Some studies have shown that as long as there is good bone quality and, in most cases, the surgery was elective (not from a traumatic injury such as a fall, a motor vehicle accident or a pathological fracture) early weightbearing as early as 7-14 days post-operatively can be done without the concern for mal or nonunion of bone [1,8,9]. In this circumstance, the patient must be in good health (no comorbidities such as diabetes, peripheral vascular disease, obesity, cancer or suffered from other injuries sustained from a trauma such as other extremity fractures or internal organ injuries), self-motivated and be compliant with a prehabilitation program that was followed for up to 6 weeks (discussed later in the article) prior to undergoing the surgery and is willing to follow a graduated weightbearing protocol(i.e.: day 7; 25% bodyweight, day 14; 50% bodyweight, day 24; 75% bodyweight, etc.....).

In traumatic ankle and foot fractures for patients with comorbidities in post-operative care, it is important to utilize crutches or a knee scooter. Crutch training can be viewed on Youtube.com. To utilize crutches properly; use a swing through gait pattern; place the crutches 2-4 inches in front of both feet, The armpits should be comfortably resting on the arm pads 2 finger width, not forcibly jammed in the shoulders. There should be a 20-25 degree of elbow flexion, and the hands are firmly gripping the handle of the crutches. Make sure the crutches are adjusted properly to your height (i.e..5'9). Bend the knee of the involved leg, push off with the good foot of the uninvolved leg through the crutches with the involved leg following close by, land on the good foot; then repeat. Try to practice crutch walking around the ambulatory surgical center or hospital before being discharged to home. Most knee scooters are available through a medical supply store or can be purchased on online websites such as Amazon or Ebay for around \$100-\$150 USD. Always use these assistive devices if you need to ambulate for any reason.

Post-operative Surgery Nutrition

Another important factor for recovery from an ankle or foot surgery is diet. A diet rich in vitamin enriched vegetables and protein will help aid and promote healing and ossification of the healing bone, tissue and skin. Vitamin C and D are important for collagen synthesis and calcium deposits to the bone. Vitamin D will increase osteoblastic formation and will help excel ossification of bone cells around the surgical fixation. Vitamin C has been also known to improve post-operative pain from surgery, even though

the mechanism of action is not truly understood, survey-based research using a VAS pain score did show that a dose of 0.5-3g/dl helped reduce pain post-operative surgical patients by to 3 points [5]. Vitamin C will also fortify collagen synthesis throughout the surgical site and help with repair of soft tissues such as muscles, capsule and bone [10,11]. According to studies, the recommended dose of Vitamin C is at least 500-1000 mg per day. An increase in the consumption of protein post operatively has also been shown to speed recovery of muscle cells. Desirable choices for protein are lean cuts of meat such as salmon, tuna, chicken, turkey, and lean cuts of beef. If cooking is an obstacle, then try consuming whey protein shakes. This option may be easier to prepare and consume. Most protein powders that are purchased over the counter already have vitamins C, D, B, E and even collagen peptide within the ingredients. Patients with foot/ankle fractures or arthrodesis should be placed on vitamin D and calcium supplementation (2000 IU/day + 1000 mg/day), respectively [10,11]. Patients with a history of habitual smoking(tobacco) and alcohol consumption should be educated to refrain from using these substances as it can contribute to non-union of bone during the healing process. Most surgeons will advise the patient to stop smoking and consuming alcohol at least 6 weeks prior to having foot and ankle surgery. These habits will be detrimental to healing post-operatively.

Scar Massage

During the initial healing process, the skin over the area of surgical repair will start to close. During most surgical procedures, after the hardware (or sutures) to fix the bone fracture or tendon and/or ligament rupture is installed, the surgeon will proceed to close the skin with the use of sutures. The skin has multiple layers. The dermal layers of the skin which are the deepest layer will be closed by sutures that are designed to be absorbed by the body and will dissolve on their own. The upper layers in the epidermis will need to be closed by a non-absorbable, tough suture or surgical staples. These will need to be removed by the surgeon upon the 1st or 2nd office/clinic check-up after the surgery. The typical time is usually between 10-12 days post-surgery to have the sutures/ staples removed. Patients should never attempt to remove surgical sutures from a surgical site on their own without consulting the surgeon first. The epidermis needs to close by way of wound healing the same way the healing of the surgical site will heal. The inflammatory phase will give rise to the proliferative phase in which the cells (macrophages, leukocytes, fibroblasts) will lay down the necessary cellular components for epithelial resurfacing and wound contraction [12]. This process starts within hours after the surgery and continues for up to several months when the skin surface has laid down the final sheet of epithelium during which point the sutures can be removed. When the skin has been biologically closed, there will be a visual confirmation by the formation of scar tissue located longitudinally across the surgical site as the "marker" of the incision that was made at the start of the surgery [12]. During the proliferation and remodeling phase of healing, many layers of collagen are laid down and then a final layer of type 3 scar tissue is what is observed when looking at the scar [12]. These skin fibers are very robust and have little flexibility when they have been initially laid down. If these scar fibers are not moved, they can become bound down to the bottom layers of the scar tissue and can cause tension pain over the surgical site. The patient can complain of pain for several weeks after the removal of the sutures from palpating the area around and on the scar. It is this tension from the many layers of scar tissue as well as the non-mobility of the skin around the scar during movement which is causing the tension pain as well as sensory impairments. A technique called scar massage may help alleviate the pain, decrease sensory impairments and increase skin mobility when

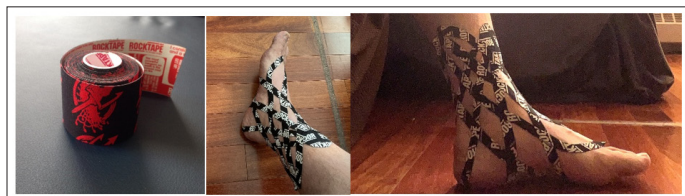
it is time to ambulate on the involved ankle/foot.

To execute scar massage, first make sure the incision site is closed and the scar is well visualized. Place your fingers parallel to the scar approximately 1 centimeter away. Press lightly down on the skin and move the fingers in a up and down motion until wrinkling of the skin can be visualized. Do this for approximately 10-15 seconds. Move to another location parallel to the scar using the same motion. Do this for the entire length of the scar. Make sure to look for wrinkling of the skin. The second step is do a transverse movement over the scar itself. Using over the counter vitamin E cream can help to decrease friction burns during the rubbing motion. Move finger lightly over the scar. Initially pressing gently down with the finger across the scar. As the scar becomes more mobile, gradually increase the finger pressure. The goal is the same as before, looking for wrinkling of the skin. Doing scar massage every day for the subsequent weeks following up to ambulation will ensure the skin will be flexible enough to move during ambulation.



Scar Massage Figure

Another modality that can be used in scar massage is the use of Kinesiology taping. Kinesiology taping applied over the closed incision can help move the underlying scar tissue underneath. The mechanism of the kinesiology tape is to lift the layers of the epidermis off the lower levels of the dermis and sub-dermis so that movement can occur under the scar tissue directly under the closed incision. If the underlying scar can be moved under the incision, then the compression and tension forces can be significantly reduced which will lead to alleviation of post-operative pain on and around the incision site.



Preparation for Ambulation

One area of concern and even anxiety for patients that have undergone foot and ankle surgery is when they will be able to walk again. Patient's always want to know this information even before the surgery is done. In some cases, patients want to be able to go back to exactly the same mobility level (work, recreational jogging, or athletic endeavors, etc...) as they were before the surgery. One way to overcome patient anxiety and boost confidence to successful transition to ambulation is the concept of prehabilitation [1,2,3]. In the concept of prehabilitation, the patient either goes to physical therapy or is given an exercise regime to follow prior to the surgery. The reason behind this is to familiarize the patient with the therapeutic exercises that the patient will be doing post-surgery. When the patient learns these exercises, then the patient can start doing them immediately leading up to and then after the ankle/foot surgery. These exercises will be open chain exercises [1,3,5,9]. Open chain exercises are non-weight bearing exercises that will be specific to strengthening muscles around

joints that are proximal to the ankle and foot such as the core, hip and knee. These muscular groups include the gluteus maximus and medius, the quadriceps, the hamstrings, gastrocnemius and solus muscles. These muscles are essential for ambulation as these are the main movers in lower extremity gait. Studies have shown that patients that take part of prehabilitation, are able to ambulate faster than someone that has not. Taking part in a prehabilitation can specifically, speed up recovery in proprioception in the foot/ankle complex. According to studies, the incidents of falls due to loss of proprioception after foot/ankle surgery is one of the biggest psychosocial concerns followed by anxiety and depression from lack of ambulation [1,8]. A strength training exercise program focused on proximal muscle groups can provide confidence and conditioning of the main muscle groups used in gait; gastrocnemius, solus, quadriceps, glute max and medius as well as core muscles of the spine and abdominal (paraspinal muscles, rectus abdominis, internal and external obliques and transverse abdominis). These muscle groups contribute to static and dynamic balance as well active gait. If these muscles are conditioned before the elective ankle/foot surgery, then a patient will have less anxiety and will be able to continue working on the exercises right after the surgery [1,3,8]. One of the biggest barriers to a successful implementation of a prehabilitation program is patient self-motivation and compliance. If the exercises are started at least 4-6 weeks prior to the surgery, then doing the exercise program every day up to and after the surgery will become a habit. Developing this habit will take self-motivation and perseverance. It is important to start as soon as possible so that the patient becomes comfortable performing each exercise with good exercise form. This will ensure a good foundation and develop into a daily habit. This habit will be important right after the surgery as the physiological aftermath sets in. The patient will experience pain as the nerve block wears off and the inflammatory stage with edema sets in. If the habit has been established to do the exercise regime, then it will not be as difficult for the patient to execute it during the post-operative time [3,5,8,9]. The patient may always start the open chain exercise program after the surgery; however, it will be easier for them to learn and execute the exercise program if they have been doing it already 6-12 weeks prior to surgery. There is evidence to support a speedier recovery when the muscles of the lower extremity and core are in good condition prior to surgery [1,3,4,6,9,13]. This applies to patients that undergo elective surgery such as bunions, hammer toes, Achilles tendon repairs or coalition corrections. Patients that undergo foot and ankle surgery due to trauma may not be able to do a prehabilitation program prior to their surgery. These patients would still benefit from an open chain post-operative therapeutic exercise program right after their ankle and foot surgery. Engaging in a therapeutic open chain exercise program will help decrease anxiety about the ability to return to ambulation as well as conditioning the gait related muscles so that there is a smoother transition from non-weightbearing to weight bearing as tolerated with no assistive devices for ambulation. Exercising everyday will help with pain modulation as performing exercise has been known to stimulate and release beta-endorphins in the brain stem. Beta-endorphin release has been examined over decades of research as the body's natural pain regulator which is released during moderate exercise intensity. Most evidence sourced research agrees with performing exercise 4-12 weeks prior to surgery (i.e., elective cases) or status post right after surgery (i.e., trauma cases) [1,3,5,9,14,13]. All of the exercises can be done with the CAM boot on for protection of the foot and ankle. For elective surgery patients that will be starting a prehabilitation program, they should be encouraged to purchase the CAM boot prior to the surgery and do the prehabilitation exercise program with the CAM boot on.

Top 6 Open Chain Therapeutic Exercises

According to evidence-based practice, the best exercises to do after foot and ankle surgery are:

1. Pelvic tilts
2. Ankle pumps
3. Clam shells (with/without a resistance band)
4. Short-arc quads
5. 4-way bilateral hip ROM strengthening (flexion, abduction, adduction, and extension)
6. 4-way ankle resistant band exercises

Pelvic Tilts

The pelvic tilt exercise is very important to the preparation of ambulation. The exercise focuses on the conditioning of the transverse abdominis and the gluteus medius and maximus muscles. The other important muscle groups that are strengthened are both internal and external oblique muscles. These muscles are commonly known as the “core muscles”. This exercise can be progressed into a table bridge to target the core muscles including the erector spinae muscles as well. The pelvic tilt exercise is done with the patient lying supine with their knees flexed and the feet flat on the table or bed. The anterior pelvic bone is rotated up toward the head by manually pulling the belly button in towards the spine so that the curve of the small of the low back is flattened against the table with the isometric contraction of the gluteus maximus muscles. For the pelvic tilt exercise, the back does not leave the surface of the table. For the table bridge, the back does leave the table as the glute and core muscles are contracted. This is a small motion and requires practice to master. See figure 1a and 1b.



Figure 1a, 1b

Ankle Pumps

This exercise has 2 benefits; 1. Helps prevent deep vein thrombus (DVT) formation right after surgery. 2. Helps prepare the lower extremity for ambulation. The calf muscles play a vital role in ambulation. The 2 major calf muscles are the gastrocnemius and the soleus muscle. The gastrocnemius is primarily used for push off force at the end of the stance phase of gait. The soleus muscle plays a role in lower leg stabilization throughout the phases of stance of gait, from loading response when the foot hits the ground, to the foot attenuating the forces and moves through the joints of the foot up to and including push off. These are essential muscles to condition before ambulation. The ankle pump exercise is easy to do. It is done while lying on bed or a couch with the foot and ankle free. With the leg totally steady and knee extended, move only the foot back towards the head so the toes are pointing towards that direction. From there point the foot down so the toes point away from you. Full excursion of range is not necessary, move the ankle so that the foot is in a neutral position, then point them away approximately 25-30 degrees of plantar flexion. Repeat each set 30-40 times. Start with 10 reps and then try to build your

endurance so that you can do 30 repetitions in one set. Wait until sutures or staples are removed and incision is closed before doing this exercise. See figures 2a and 2b.



Figure 2a, 2b

Clam Shells

Clam shells is an exercise that is intended to condition the hips such as the gluteus medius and maximus. It will also condition other hip muscles needed for ambulation such as the tensor fascia latae and adductor muscles. This exercise should be done on both sides of the hips (the hip of the involved ankle and foot and the hip of the uninvolved foot and ankle). For this exercise, in the beginning, you don't need to use a resistance band. Focus on slow and steady motions of opening and closing of the legs. Start the exercise by lying on a bed or couch. Both knees are bent at approximately 90 degrees, involved hip on top. Start by slowly opening the top knee and rotate only the top hip until the knee is almost pointing towards the ceiling. Hold for 2 secs and slowly return to the starting position. The feet should always remain in contact with each other, do not separate the top leg from the bottom leg, only the knee will open and close. Perform 3 sets of 10 repetitions each. When the exercise becomes very easy to do, you may add the theraband above the knees to increase difficulty. See figures 3a and 3b



Figure 3a, 3b

Short-arc Quads

Short-arc quads focus conditioning to the knee joint. As with the hip, the knee joint bears the weight of the upper body, pelvis and upper lower leg. It is essential that the muscles around the knee joint are properly conditioned for ambulation before attempting to walk [1,3,9]. The muscles that contribute to stability and muscle power to the knee joint during ambulation are the quadriceps muscles (vastus lateralis, Vastus intermediate, rectus femoris and vastus medialis aka VMO). The other muscles that contribute to knee extension are the gracilis (hip adductor) and

semitendinosus(hamstring). Short arc quads focus the conditioning in the last 10-15 degrees of knee extension which is needed in midstance of gait as the body translates forward over the foot and is in preparation for push off phase of gait. To start the exercise, use a couple of pillows under the knee so the knee is in a flexed position. The knee can be in as much as 10 degrees of flexion. To execute the exercise, try pushing down on the pillows with the knee and the same time, contract the quads and straighten the knee until in full knee extension. Hold for 1-2 seconds and return to the flexed knee position. Do 3 sets of 10 repetitions. See figure 4a and 4b.



Figure 4a, 4b

4-Way Hip Strength and Conditioning Exercises

The hip is another important joint for gait. The hip muscles that are important for gait are the gluteus maximus, gluteus medius, and hip adductors [1,5,9]. The 4 motions that activate these muscle groups are hip flexion, abduction, adduction and extension. All 4 motions are needed for effective and stable gait. Each movement can be done on bed or sofa and should be done for 3 sets and 10 repetitions each. Focusing on exercise form and complete motion is necessary. Starting with hip flexion, keep the back flat on the bed and raise the leg with knee extended to approximately 45 to 90 degrees of flexion. Hold for 1-2 seconds and lower down smoothly. Hip abduction is a difficult exercise for most people. The focus should be to keep the hip rolled forward, not back and keep the knee in an extended position. Raise leg to approximately 30-45 degrees. Hold for 1-2 seconds and lower down. In hip extension, focus on keeping knee extended and foot rotated down. Do no arch the lower back. Raise to approximately 10-15 degrees and lower down. In hip adduction, keep knee extended and foot straight. See figures 5a, 5b, 5c, 5d



Figure 5a, 5b, 5c, 5d

4- way Resistant Band Ankle Strengthening Exercises

These exercises are very critical part of the prehabilitation exercise program as these exercises target the conditioning of key ankle and foot muscles such as the anterior and posterior tibialis, gastrocnemius, soleus and the peroneal muscles. These muscles control the ankle and foot in standing and gait, but also aid in proprioception and decrease postural instability of the foot and ankle during balance and anti-fall physiological mechanism [8,10]. Successful ambulation after foot and ankle surgery will rely not only on the proximal muscles of the lower extremity, but also on the muscles that have a direct function to range of motion and functional gait of the muscles of the ankle and foot. If the foot or ankle injury sustain was a traumatic injury, these exercises should be reversed in the later portion of the recovery period when nearly full active range of motion of the ankle is established. The 4-way resistance band exercises for the ankle are dorsiflexion, inversion, eversion and plantarflex. The movements of dorsiflexion and inversion should be done with precision as these muscles will atrophy first after the foot/ankle surgery. These muscles will be needed to assimilate a quicker return to a functional ambulation of the involved extremity. The exercise will require the resistance band to be secured in the opposite direction of the movement to provide appropriate resistance. Securing the resistance band to a door or under a heavy weight will be necessary. Each exercise should be done of 10 repetitions and 3 sets each. See figures 6a,6b,6c,6d.

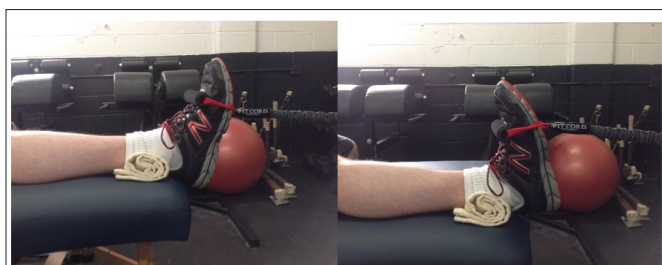


Figure 6a, 6b: Anterior Tibialis Strengthening Exercise

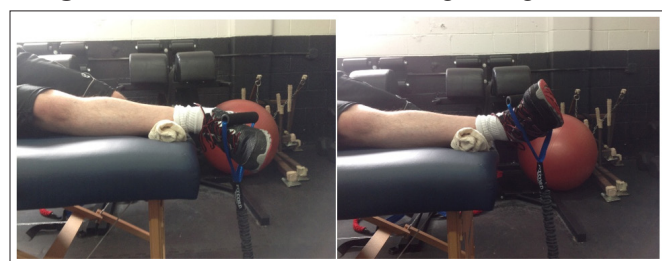


Figure 6c, 6d: Posterior Tibialis Strengthening

Conclusion

Foot or ankle surgery can be a life changing process. It is important to plan accordingly if the surgical procedure is elective. Based on the available evidence on post-operative surgery, the most contributing factors of prolonged functional limitation and patient disability after surgery is physical inactivity, malnutrition, poor fitness levels and adverse Psychological. feelings such as depression and anxiety. These negative physiological attributes come from the limitation of mobility [2,3]. The theory behind prehabilitation is to enhance the well-being and fitness state of the patient before undergoing surgery. This can aid in positive behavior modification and compliance towards a faster recovery and as well as retuning to ambulation and previous functional status prior to the surgery [2,3,9]. In cases that are traumatic in nature such as falls, MVAs or crush injuries, preparation is not possible. However, early return to physical activity needs to be

encouraged by the surgeon. Weightbearing on the operative foot or/and ankle can take as much as 2 months. However, the patient should be encouraged to start a therapeutic exercise program targeting proximal muscle strengthening as well as incorporating modalities such as cryotherapy, scar massage, kinesiotaping, and strength and conditioning/therapeutic exercise programming for core and proximal LE gait conditioning. The graph (figure 6) depicts the patient's level of independence before and after surgery. Patients undergoing elective ankle or foot surgery (i.e... hallux valgus correction, hammer toe correction, Achilles tendon repair etc..) that are prepared for the surgery: have been engaged in a prehabilitation program, have access to cryotherapy including and ice machine and ice packs are represented by line c. Patients that have undergone traumatic ankle or foot injury and repair (ankle fracture ORIF, Calcaneal ORIF, Lisfranc repair etc..), but were encouraged by their surgeons to start self-recovery with modalities and therapeutic exercise program targeting open chain exercises of the lower extremity, are represented by line a and d. The patients that were not prepared and either did not under go any self-recovery strategies, incorporate any exercise programming or were discouraged by their surgeon not to be physically active are represented by line b. Based on the literature review done with preparing this article, there was no evidence that discusses any detriments or contraindications in doing immediate self-recovery or doing an open chain therapeutic exercise program right after foot or ankle surgery [3,9,15-18].

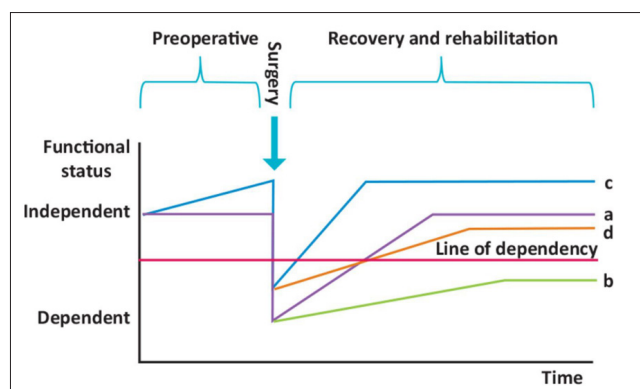


Figure 7

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