Commentary 1

Prevention and Management of Joint Contractures

Xinmai Yang\textsuperscript{1*} and Jinxi Wang\textsuperscript{2}

\textsuperscript{1}Institute for Bioengineering Research and Department of Mechanical Engineering, University of Kansas, USA
\textsuperscript{2}Department of Orthopedic Surgery, University of Kansas School of Medicine, USA

\textsuperscript{*}Corresponding Author: Xinmai Yang, Institute for Bioengineering Research and Department of Mechanical Engineering, University of Kansas, Lawrence, KS, USA, Email: xmyang@ku.edu

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Introduction

Tissue contractures are commonly caused by the shortening or stiffening of muscles and/or other connective tissues. When a contracture occurs in muscles, tendons, or ligaments around a joint, the range of motion (ROM) of the joint will be restricted. The restriction of ROM can result in deformity, reduced motor skills, and loss of joint function for daily activities. For example, a knee flex contracture of as little as 5° will result in a limp [1], and >15° will require surgical intervention [2-5]. A joint contracture is also often followed by increased pain over the progress of the disease, and eventually leads to disability.

The pathogenesis of joint contractures varies depending on multiple factors. These factors can be intrinsic, such as genetic disorders and neurological disorders, or extrinsic, such as reduced use of a joint and scarring in a joint after traumatic injury [6]. For example, cerebral palsy or stroke may result in the restricted movement of a part of body or limited ROM in a joint; nerve damage may cause an imbalance of the strength between different muscle groups, resulting in reduced active joint ROM as the stronger muscle group often dominates the movement; muscular dystrophies caused by inherited disorders may damage and weaken muscles over time, leading to joint contractures. The key extrinsic factor contributing to joint contractures is injury. Scarring in a joint can occur
after traumatic injury. Excessive scar tissues in the joint can restrict the mobility of the joint, and eventually induce post-traumatic joint contracture or arthrofibrosis, one of the major complications after a joint injury or surgery. Reduced use of a joint and static positioning, for example, prolonged immobility from a critical illness, may be the most common pathogenesis for joint contractures. This factor contributes to the formation of nearly all joint contractures because once a joint contracture develops, patients are often reluctant to actively mobilize the joint due to discomfort/pain, resulting in reduced use of the joint and aggravated condition of contracture. Frequently, several factors may contribute to the joint contracture at the same time. Hence the prognosis of a joint contracture can be quite different from case to case.

**Current Management of Joint Contractures**

Currently, the prevention and management of joint contractures are largely limited to physical therapies and surgeries. Medications are rarely used, but can be taken to relieve pain and inflammation. Most of the treatments aim to reduce the build-up of fibrosis and relieve the stiffness due to the scarred tissue or muscle shortening. While there are different opinions on how effective some of the interventions are, there are some generally accepted interventions that may reduce the impact of joint contractures.
Traditional Non-Technology-Assisted Rehabilitation

Most traditional rehabilitation approaches, which are also most frequently used, do not involve the use of modern technologies. These approaches, including stretching, active movement, or passive movement therapy, have historically been an integral part of the physiotherapy management of patients with joint contractures. Both stretches and passive movement therapy currently are the main physiotherapeutic interventions to treat contracture. These interventions can assist in the management of pain and improve joint ROM and functions. The general guideline is that these interventions should start as early as possible to prevent joint contracture. With sufficient exercises and stretches, patients may avoid open-surgery [7].

At the early stage, the development of a routine for daily walking/standing to stretch the joint is an effective way to manage joint contractures. Such motions have been documented effective in slowing down the progression of contractures [8]. However, for many elderly people, the pain following the stretching often prevents them from the daily routine. In case prolonged stretching is needed, bracketing or splinting may be used overnight to help slow down the progression of contracture.

Passive movement therapy, or assisted ROM exercise, is usually performed by a trained physical therapist. These
treatments are for patients who has trouble to actively move their joints. This therapy may help to promote the overall health of a joint. Passive movement therapy has been widely performed to treat and prevent contractures in the wrist, knee, hip, and shoulder, etc.

Massage is probably the most ancient method to reduce the build-up of fibrosis and the stiffness of the joint, and it can pretty effective in some cases [9]. Massage may promote collagen remodeling by applying pressure to scars, help to reduce pain, and provide flexibility to the scar [10]. Massage is applied on the surface of the body. When scar tissue is deep inside the body, deep massage needs to be performed to achieve the desired effect. This process may accompany discomfort and pain because more pressures are needed to be applied to the surface tissue in order to stimulate the deep tissue.

Although active stretching and manual therapies such as passive movement therapy and massage are so widely used, recent research was unable to demonstrate the benefits of passive movement [11-13]; The evidence is also compelling that stretch does not have clinically meaningful effects on joint mobility [14,15]; or there is scarce scientific data in the literature to support scar massage [16].

Technology-Assisted Rehabilitation

With the development of the modern technology, several rehabilitation principles have been developed and
employed in the clinic. These principles usually utilize one or a mixture of external energy sources to stimulate muscles and excessive fibrosis in the joint to soften the stiffened joint. The utilization of external energy sources allows the joint to be stimulated with a frequency and amplitude that cannot be achieved manually. The most frequently used energy sources include laser, ultrasound, and vibration.

Low level laser therapy (LLLT) has been used for musculoskeletal disorders [17,18], and demonstrated to improve the joint ROM after the development of a joint contracture [19,20]. LLLT has been shown to possibly improve pain threshold, increase blood circulation, and reduce inflammation. However, this technique is not ideal for noninvasively removing fibrosis in large joints because fibrosis in large joints are not on the surface of the skin, making it difficult for laser to penetrate.

Vibration therapy, including whole-body vibration (WBV) or local vibration (LV), is a very popular practice in sport, fitness and physiotherapy [21]. Vibration therapy usually utilize mechanical vibration less than 100 Hz to stimulate muscles. Recent research has demonstrated that when vibration is applied to adhesions, scar tissue, and the surrounding muscle, local nerves can be stimulated to help improve the function of muscle tissue that has been affected by the formation of scar tissue [22,23]. However, the clinic evidence is insufficient to support the effectiveness of vibration therapy at this point [24].
Ultrasound therapy, especially low-intensity-pulsed ultrasound (LIPUS) therapy, is an ultra-popular technique for musculoskeletal disorders, including removing scar tissues to relieve joint contractures. One important advantage of ultrasound therapy is that ultrasound can easily propagate deep into soft tissue to directly treat deep tissues. Frequently operated at a frequency of MHz, ultrasound may promote cartilage repair, relieve pain, and improve physical function [25,26], including ROM [27]. Experimental data also show that ultrasound may boost the mRNA expression of type II collagen, aggregan, and transforming growth factor (TGF)-β in chondrocytes [28,29]. However, the effectiveness of ultrasound is highly controversial and inconsistent. As a result, some review articles concluded that there seems to be little evidence to support the use of ultrasound therapy in the treatment of musculoskeletal disorders [26].

Both vibration therapy/vibration training and ultrasound therapy are very popular in rehabilitation because they are very benign techniques and easy to operate. The potential damage to the joint is almost non-existing. Both techniques share the same theoretical foundation, which is biomechanical stimulation. Numerous studies have shown that mechanical forces can stimulate live cells and activate their functional pathways [30-32]. However, the optimal magnitude and frequency of the mechanical stimulation is still unclear for clinical use. As a result, these
types of therapies, especially ultrasound therapy, has been heavily criticized for failing to demonstrate significant clinical benefits.

**Surgery**

When a joint contracture becomes very severe and physiotherapies are unlikely to improve the condition, surgical interventions should be considered. In comparison with rehabilitation techniques, surgery, if done correctly, can more reliably reduce joint contractures and recover joint ROM and other functions. Surgeries are mostly performed to release post-traumatic joint contractures, which are often induced by scar tissue, or arthrofibrosis. For example, the criteria for assessing stiffness requiring surgical treatment is defined as having a flexion contracture of 15° or flexion of less than 75° in knee joint after knee arthroplasty [33]. For upper limb such as the hand and elbow, the threshold contracture value for surgical intervention is generally larger because contractures of upper limb do not affect functions as much as the lower limb. Nevertheless, surgical removal of adhesions can drastically improve ROM in patients with arthrofibrosis if done properly [2]. In addition, aggressive rehabilitations are often required after surgery.

Surgical procedure to reduce joint contracture can be complex, primary due to the recurrence of scar tissue after
surgery, which poises a great challenge for surgical treatment, and multi surgeries are often needed [7]. Also, the timing for surgical intervention of joint contracture is important. While for rehabilitations, it is the early, the better; for surgical intervention, early treatment may have deleterious effects. Therefore, surgeries are usually performed at late stages or when fibrosis is well established.

**Challenges and Prospects**

Surgical interventions can often provide satisfying improvement on the restoring of the joint functions. However, it is a destructive process and always comes with a list of risks, such as reactions to medication, bleeding, etc. There is always a chance that fibrosis may reoccur in the joint to make the contracture or pain worse. In addition, multiple surgeries are often needed in order to treat the contracture. For these reasons, rehabilitations are usually the first choice to restore joint functions.

Rehabilitations are widely used by physical therapists and well accepted by patients, and some small scale clinical trials have reported the benefit of rehabilitation. However, many of them, including stretching, passive movement, ultrasound therapy and vibration therapy, could not demonstrate sufficiently significant clinical benefit [11-16,24,26] to joint contractures. It seems that there is a great inconsistency and uncertainty about the exact effect of rehabilitation on joint contractures. Nevertheless, rehabilitation procedures are routinely recommended by
doctors and used by physical therapists, as it is generally accepted that rehabilitations may help to reduce joint contractures.

Currently, clinicians and scientists in the field of orthopedic surgery and rehabilitation medicine are working together to better understand the pathogenesis of contracture and scar formation, optimize the existing non-surgical and surgical procedures, and develop novel therapeutic protocols to reliably and consistently achieve more successful treatment for joint contractures [34-36].

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