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MYOFASCIAL PAIN AND TREATMENT: ORIGINAL RESEARCH

Immediate effect of myofascial release on range of motion, pain and biceps and rectus femoris muscle activity after total knee replacement

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ABSTRACT

Objectives: The role of a myofascial release (MFR) on flexion contractures after total knee arthroplasty (TKA) has not yet been elucidated. Therefore, the purpose of this study was to determine its immediate effect on such patients.
Methods: In this A-B single subject experimental study, 33 TKA's patients with knee flexion contracture had their *gluteal, posterior fascia lata, posterior crural and plantar fasciae* released. Patients' knee range of motion (KROM), pain and muscle electric activity were assessed pre- and post-intervention.
Results: An increase in electric activity of the biceps femoris muscle was identified after treatment (pre RMS = 0.087 ± 0.066 V; post RMS = 0.097 ± 0.085 V; p = 0.037). Mean gain of KROM was 5.72 ± 6.27, correspondent to an 11.9% improvement (p = 0.01). Eight subjects had their pain decreased on 56.9% (p = 0.04).
Conclusions: MFR increased muscle activity, reduced pain and improved the KROM of TKA patients. Thus, MFR is a useful resource of rehabilitation after TKA.

1. Introduction

Total knee arthroplasty (TKA) is one of the most frequent treatments for degenerative knee diseases, such as osteoarthritis (Collins et al., 2014; Lungu et al., 2014; Schachea et al., 2014). Amongst surgical complications, stiffness, swelling, and pain represent a challenge to rehabilitation therapists during functional recovery. Stiffness is one of the most common adversities faced after TKA that frustrates both healthcare professionals and patients (Su and Su, 2013). The concept of stiffness is broad and reflects surgeons' and patients' expectations for TKA results. This is because, throughout the years, a greater mobility of the knee is anticipated following surgery (Gonzalez Della Valle et al., 2007; Koh et al., 2013; Witvrouw et al., 2013). According to Ghani et al. (2012), the stiffness of the knee has received different definitions, including being described as a flexion smaller range less than 70°, with or without a combination of limited extension, for instance of 15°. In 2013, the Knee Society, an American orthopedic association, defined stiffness as a “limited range of motion (ROM) as reported by the patient and demonstrated in a physical examination. With extension limited to 15° short of full extension or flexion <90° (not applicable if the preoperative range of motion < 75°)” (Healy et al., 2013).

The prevalence of stiffness after TKA varies between 1.3% and 15%, according to diagnostic criteria (Bonutti et al., 2008). It is usual to experience satisfactory results through physical therapy interventions such as stretching and walking and re-education. If function remains compromised following aggressive therapy, other techniques may be explored to improve the patient's ROM, such as dynamic stretching and serial casting (Ghani et al., 2012; Scuderi, 2005; Yercan et al., 2006). In other cases, a new surgical procedure is necessary, including manipulation under anesthesia, arthroscopic release, or revision of total knee arthroplasty (Healy et al., 2013; Scuderi, 2005).

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Several factors may influence the onset of flexion contracture and these factors may be related not only to the surgical procedure, but also to the patient's inherent characteristics (Su and Su, 2013). Pain management, prosthetic kinematics, posterior osteophytes, malalignment, implant size and overstuffing (i.e., cement surgery filling of the femoral arthroplasty components) may contribute to extension limitation. In addition to posterior cruciate ligament (PCL) shortening, limited pre-operative ROM (Laskin and Beksac, 2004) and quadriceps weakness (Favre et al., 2014). Limited ROM, especially limited extension, is implicated in functional restriction. Patients with a flexed knee, overload their quadriceps muscle and the patellofemoral joint (Su and Su, 2013). They also develop fatigue which forces the patients to walk shorter distances. As a result, a premature quadriceps weakness (Serrão et al., 2012). Furthermore, after TKA a flexion contracture after TKA has been associated with an early degeneration of the contralateral knee (Felson, 2013).

Myofascial release (MFR) interventions have been receiving attention among manual therapists as a useful tool to treat stiffness (Ajimsha et al., 2015; Ćosić et al., 2014; Grieve et al., 2015; Myers, 2010; Pratelli et al., 2015). Over the last decades, several studies have discussed fascia's role and the consequences of myofascial interventions on connective tissue structures (Ercole et al., 2010; Masi et al., 2010). According to McKenney et al. (2013), MFR can be defined as the graded stretch of soft tissue while the patient remains passive during its application. In its indication, the MFR has applied several musculoskeletal dysfunctions including neck pain, hip dysfunction, and epicondylitis (Chaitow, 2017). Moreover, the discussions over the effects of MFR have been enhanced by its contribution to pain reduction (Ćosić et al., 2014; Guarda-Nardini et al., 2012); both functional and ROM improvement (Ajimsha et al., 2014; Picelli et al., 2011; Pratelli et al., 2015), on tissue resistance tone (Luomala et al., 2014). Various systematic reviews have reported that the quality of MFR studies ranged from lower-quality to higher quality (McKenney et al., 2013).

According to the tensegrity concept described by Myers (2010), it is possible to intervene in deep fascial structures through the use of MFR. Therefore, this strategy differs from others by the premise that myofascia is a continuous structure. When released, it responds systemically by attaining a balance between forces of tension and compression along its entire chain. Also, MFR allows an integrated approach of the patient, since, the beneficial effects of the treatment with a single intervention are observed, along with the myofascial network (Myers, 2010). Despite the publication of rehabilitation studies focused on a gain of movement and function after TKA, the current scientific literature still lacks consistent discussions about the posterior myofascial chain's contribution on flexion contractures of the knee after total replacement. Furthermore, there are insufficient studies on myoelectric activation following the MFR. Therefore, a better understanding of the effects of MFR on knee range of motion (KROM), pain and electrical muscle activity following TKA may contribute to the acceptance of new approaches in the physical therapy's program. Based on this premise, the aims of this study were: 1) to investigate the immediate effect of a superficial back line MFR intervention on flexion and extension KROM. 2) to assess knee pain. And 3) to analyse root mean square (RMS) electrical activity of *rectus* and *biceps femoris* of TKA patients, all pre- and post-MFR intervention.

2. Method

This study utilises an A-B single subject experimental design, in which 33 subjects previously submitted to TKA participated. Patients were then forwarded to the Physical Therapy Services of the Rehabilitation Unit of Instituto Nacional de Traumatologia e Ortopedia Jammil Haddad (INTO), Rio de Janeiro, RJ.

A sample of 33 individuals submitted for TKA from both genders, who presented a flexion contracture of at least 5° after surgery and who were authorised by the surgeon to initiate the rehabilitation process. Exclusion criteria included cognitive impairment, extrapyramidal syndrome, prior surgical procedures on the knee, revision TKA, complex pain regional syndrome, acute infection or deep venous thrombosis, scar dehiscence, implant failure or periprosthetic fracture, rheumatoid arthritis, Charcot arthropathy and motor neuron diseases.

Subjects were recruited after stitches removal and surgical staff evaluation at the *specialized knee care center*. Patients received information about the experimental procedure and signed a written consent form. The experimental treatment was executed up to 8 weeks following surgery.

The recruitment process took place between September/2014 and July/2015 and involved 539 TKA patients. From those, 48 had limited extension of the operated knee and, therefore, were screened for exclusion criteria. A total of 15 patients were excluded, 6 for rheumatoid arthritis, 3 for previous surgeries, 2 for Parkinson's disease, 2 for hemiplegia and 2 for an acute infection of the knee. In the end, this study included 33 patients.

This study was submitted and approved by the research ethics committee of the Instituto Nacional de Traumatologia e Ortopedia Jammil Haddad (INTO) under inscription number 22731413.4.3001.5235, according to the 466/12 resolution of the Brazilian Health Nacional Council.

2.1. Intervention

MFR was based on the description proposed by Myers (2010) on the Anatomy Trains concept in the lower limb superficial back line. The subjects sat in a prone position, with the legs extended and the feet hanging off the edge of the treatment table. Arms were held alongside the body and the head placed in a neutral position. Treated structures included gluteal, posterior fascia lata, crural and plantar fasciae. MFR was performed only once directly over the patient's skin in the craniocaudal direction and respected the spatial disposition of fascial tissue of the inferior limb. The procedure was divided into four steps to facilitate comprehension.

Step 1 (Gluteal Fascia): The researcher's hands were positioned simultaneously on the superior and inferior portion of gluteus maximus muscle, with fingers facing each other. To handle out the muscle, hands were drawn nearer towards each other and upwards. Then, while maintaining tension, sliding movements were performed from side to side (see Fig. 1A).

Step 2 (Posterior Fascia Lata): Posterior muscles of the thigh were tensioned out at the ischial tuberosity. Medial and lateral sections of the muscles were individually manipulated with side to side sliding throughout the extension. However, in opposition to the gluteal fascia, hands were moved in opposite directions; if one was pulling the muscle, the other was pushing it away (see Fig. 1B).

Step 3 (Posterior Crural Fascia): Fingertips were positioned on both sides of the gastrocnemius muscle. Hands were drawn towards each other and upwards to input tension to the myofascial structure. A sliding movement similar to step 2 was then performed from origin to insertion, including the calcaneal tendon (see Fig. 1C).

Step 4 (Plantar Fascia): Initial contact of the hands occurred on the lateral and medial edges of the superficial layer of the plantar fascia. Fingers were perpendicularly introduced between plantar aponeurosis and the intrinsic muscles of the first and fifth toes. Following this, the fingers slid in a calcaneal-toes direction (see Fig. 1D).

After the intervention, patients were asked to stand for 30 s. This

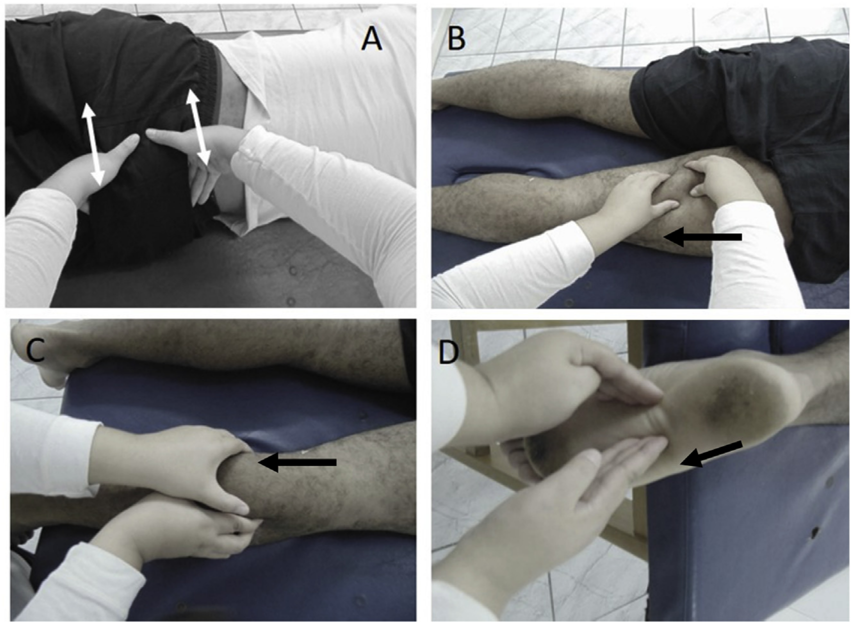

Fig. 1. Myofascial intervention (A) Gluteal Fascia and intervention's direction [white arrows] (B) Posterior Fascia Lata; (C) Posterior Crural Fascia and (D) Plantar Fascia. [black arrow] Direction of MFR.

orientation was to allow adaptation and redistribution of tensions throughout the myofascial train. Application of the technique took no longer than 3 minutes. Immediately after MFR application, subjects had their flexion/extension KROM, knee pain and electrical muscle activity measured by photogrammetry, a visual analogue scale and electromyography (EMG), respectively, as described in the following section. Before MFR, patients were also screened for the variables mentioned above. The time between the second photogrammetry and the new EMG was approximately 5 minutes.

2.2. Measurement instruments

2.2.1. KROM

Photogrammetry was used to assess knee flexion and extension KROM -intervention. In this study was used a Sony DSC-W50 digital camera with 6.0-megapixel resolution. Camara was placed in a 15m2 room at 0.85 m height above the ground and a distance of 1.5 m from the treatment table. The software Kinovea® version 0.8.15 (Baude et al., 2015; Damsted et al., 2015; Padulo et al., 2015), downloadable free at http://www.kinovea.org/en/downloads/, quantified the lateral view angular displacement of the intervened leg. Yellow passive markers of 20 mm highlighted by a black background for contrast were fixed at the greater trochanter, femoral lateral epicondyle and lateral malleolus. Patients were in prone position for image registration of the maximum active flexion and extension movement pre- and post-intervention. The hips were immobilised to avoid postural compensations. Initial and final KROM (KROMi and KROMf respectively), i.e., before and after the intervention, were calculated by subtracting the maximum extension angle from the maximum flexion angle in prone (Ajimsha et al., 2015). To calculate the change percentage analysis of KROM (CPA-KROM) the following formula was applied (Ajimsha et al., 2014):

$$\text{KROM} = \text{maximum extension angle} - \text{maximum flexion angle} \quad (1)$$

$$\boldsymbol{CPA} - \boldsymbol{KROM} = \left[\frac{(\mathbf{KROMf} - \mathbf{KROMi})}{\mathbf{KROMi}}\right] \times 100, \quad (2)$$

Negative values indicated reduction, whereas positive values indicated increase in KROM.

2.3. Knee pain analysis

To assess pain, a visual analogue scale (VAS) identified by a 100 mm line with anchors on both ends was applied. One end was marked ‘no pain’ and on the other ‘worst imaginable pain’. Patients were asked to indicate the magnitude of knee pain before (KPb) and after (KPa) intervention. Then, knee pain percentage analysis (KPPA) was performed according to the formula below.

$$\boldsymbol{KPPA} = \frac{\boldsymbol{KPb} - \boldsymbol{KPa}}{\boldsymbol{KPa}} \times 100,$$

This operation redefined discrete values into continuous values expressed as a percentage, thereby facilitating interpretation and statistical analysis. Positive KPPA values specified pain reduction and negative ones, pain increase after intervention.

2.4. Electromyography

For data acquisition of surface electromyography, an EMG400C device (common-mode rejection ratio>100 dB, EMG System® – Brazil) with pre-amplified differential electrodes and bipolar input (20 times gain), connected to a USB NI-6229 16 bits analogue-to-digital converter (National Instruments®) were installed to a computer for synchronisation. Self-adhesive Ag/AgCl electrodes (10 mm diameter disc) associated to a conductor gel were positioned on the patients' skin according to the recommendations of Surface EMG for the Non-invasive Assessment of Muscles (SENIAM)'s for rectus and biceps femoris muscles (available from http://seniam.org/leg_location.htm). Skin preparation included trichotomy (if necessary) and cleaned alcohol, to achieve a reasonable level of contact between the electrode and skin. Electrodes were not removed during MFR due to its high adherence and did not compromise the intervention. On each channel was defined a sampling rate of 1.0 kHz. Signals were recorded and analysed in both time and frequency domains, algorithms were written in SuiteMYO (PhD2®) version 1.0

platform for Windows®. Patients performed a series of three consecutive and independent maximal voluntary isometric contractions that lasted 6 s each. An interval of 30 s of rest between the contractions was set as a means of minimising fatigue. After patients seated, the knee was positioned at 90° of flexion and fixed to avoid movement during contractions. The raw EMG signal for each muscle component was rectified and filtered (4th order, bi-directional band-reject 59–61 Hz digital Butterworth filter and a 2nd order, bi-directional, low-pass 10 Hz cut-off frequency digital Butterworth filter) to create a linear envelope. The signals were then averaged and analysed. Root mean square (RMS) values were calculated and expressed in volts (V). After this, the signals were evaluated and extracted root mean square values, expressed in volts (For data acquisition of surface electromyography, an EMG400C device (common-mode rejection ratio>100 dB, EMG System® – Brazil)) with pre-amplified differential electrodes and bipolar input (20 times gain), connected to a USB NI-6229 16 bits analogue-to-digital converter (National Instruments®) were installed to a computer for synchronisation. Self-adhesive Ag/AgCl electrodes (10 mm diameter disc) associated to a conductor gel were positioned on the patients' skin according to the recommendations of Surface EMG for the Non-invasive Assessment of Muscles (SENIAM)'s for rectus and biceps femoris muscles (available from http://seniam.org/leg_location.htm). Skin preparation included trichotomy (if necessary) and cleaning with alcohol, to achieve a good level of contact between the electrode and skin. Electrodes were not removed during MFR due to its strong adherence and did not compromise the intervention. On each channel, a sampling rate of 1.0 kHz was defined. Signals were recorded and analysed in both time and frequency domains, algorithms were written in SuiteMYO (PhD2®) version 1.0 platform for Windows®. Patients performed a series of three consecutive and independent maximal voluntary isometric contractions that lasted 6 s each. An interval of 30 s of rest between the contractions was set as a means of minimising fatigue. After patients were seated, the knee was positioned at 90° of flexion and fixed to avoid movement during contractions. The raw EMG signal for each muscle component was rectified and filtered (4th order, bi-directional band-reject 59–61 Hz digital Butterworth filter and a 2nd order, bi-directional, low-pass 10 Hz cut-off frequency digital Butterworth filter) to create a linear envelope. The signals were evaluated and extracted root mean square values, shown in volts (V).

2.5. Outcomes

The primary outcome is the KROM (CPA-KROM), while knee pain (KPPA) and myoelectric activity of rectus and biceps femoris muscles (mean RMS) are secondary outcomes. All three variables were used to address the therapeutic effect of the myofascial maneuver.

2.6. Control variables

The control variables age, gender, the presence of osteoarthritis of the contralateral knee, weight, height, body mass index were collected, and previous deformity of the operated knee. Surgical information such as a type of incision, implant, fixation, patellar coverage (if executed), length of hospital stay, and surgery duration was also retrieved. Institutional records were consulted when necessary.

2.7. Statistical analysis

The SPSS 20 IBM software executed the statistical analysis. Anthropometric and sociodemographic data were described as central tendency statistics and standard deviation. Tabled data were submitted to an adherence test or normality test (Kolmogorov-Smirnov) that identified all variables as normally distributed. A two-tailed *t*-test compared mean values before and after intervention of RMS, CPA-KROM and KPPA. A minimum sample size of 33 individuals were calculated, considering an effect size of 0.5, α error of 0.05 and power (1-β) of 0.8. Significance level was defined as a 95% confidence interval ($p \leq 0.05$).

3. Results

3.1. Sample characteristics

The sample presented a mean age of 68.2 years (SD ± 7.85), with a 67% female makeup. Average body mass was 73.6 Kg (SD ± 12.27), and 1.55 m (SD ± 0.97) height, with a body mass index of 30.27 (SD ± 4.31), thus, indicating that most patients were moderately obese.

Moreover, 60.6% of the subjects had contralateral knee osteoarthritis. Patient's waiting time for surgery was of 4.53 years (SD ± 0.97) – a fact that highlights possible deterioration of the knee and its function. Also, 39.4% of the patients had a valgus deformity of the knee before surgery, while 42.4% had varus deformity. Six subjects (18.2%) presented no alterations of knee alignment.

The most common implant utilised was the posterior stabilized type (90.9%), with a rotatory platform (70%) and a knee medial parapatellar approach (94%). All implants were cemented and 8% did not receive a patellar component. Surgeries lasted 140 ± 19 min and length of hospital stay was 5.3 ± 1.72 days (see Table 1). In 51% of the cases, the surgeons operated the left knee of the sample.

3.2. Myoelectric activity

Results indicate an increase in biceps femoris muscle recruitment from 0.088 ± 0.067*V* to 0.101 ± 0.085*V* after the intervention ($p = 0.037$) (see Table 2). The rectus femoris muscle also exhibited increased activation from 0.077 ± 0.053 V to 0.083 ± 0.055 V. However this difference was not statistically relevant ($p = 0.167$) (see Fig. 2).

3.3. KROM

Data indicate an increase of 5.7°± 6.3 in KROM after myofascial release. That corresponds to an 11.9% improvement, from 54.7° to 60.4° ($p = 0.01$) (see Table 2).

Table 1
Surgical data (n = 33).

Implant Type	Frequency (n)	Percentage (%)
Cruciate Retaining	1	3
Posterior Stabilized	30	90.9
Semi-constricted	2	6.1
Platform	Frequency (n)	Percentage (%)
Rotating	23	70
Fixed	10	30
Approach	Frequency (n)	Percentage (%)
Sub-vastus	1	3
Parapatellar	31	94
Mid-vastus	1	3
Patellar Implant	Frequency (n)	Percentage (%)
Yes	27	82
No	6	18
Operated knee	Frequency (n)	Percentage (%)
Right	16	49
Left	17	51

Table 2
Mean KROM and RMS values pre- and post-MFR.

	Pre	Post	P value
KROM	54.7°	60.4°	***0.01***
	Change Percentage Analysis (KROM) 11.9%		
EMG (RMS)	Rectus femoris 0.077 V (±0.052)	Rectus femoris 0.083 V (±0.055)	*0.167*
	Biceps Femoris 0.088 V (±0.066)	Biceps Femoris 0.101 V (±0.085)	***0.037***

The significance of italics is p8 <8 0.05 and highlight outcomes.

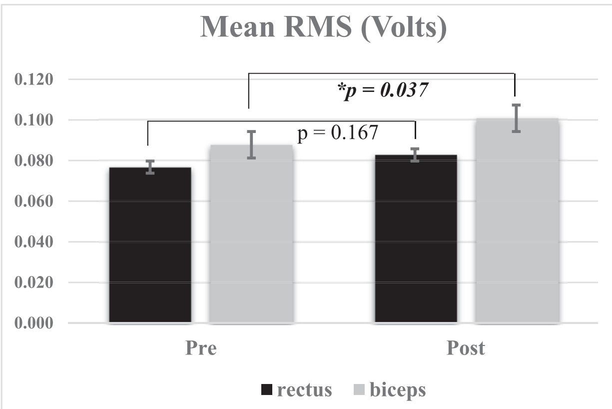

Fig. 2. Average RMS values for rectus and biceps femoris muscles before and after myofascial intervention (Volts). An increase in electric activity of rectus and biceps femoris muscles was identified after treatment, although only the latter (pre - $V = 0{,}087 \pm 0{,}066$; post - $V = 0{,}097 \pm 0085$) was statistically significant ($p = 0{,}037$).

3.4. Knee pain

Most of the subjects (n = 22) did not report pain before the experiment. A total of 8 participants had their knee pain decreased in 56.9% (see Table 3). The KPPA of a single patient increased from 40% to 80% after the experiment. Moreover, two patients maintained the same KPPA pre and post-intervention.

4. Discussion

This investigation aimed to assess the acute effect of a myofascial intervention performed on the posterior superficial train of patients with flexion contracture after TKA over KROM, knee pain and myoelectric activity. Results indicate that the myofascial intervention promotes an immediate increase in mobility. Our data highlighted a significative improvement in KROM of 5.7°. However, this may not substantiate a quick clinical gain. Nonetheless, since we aimed to evaluate the immediate effect of MFR, its prolonged action was not observed in this study. It is possible that recurrent sessions of MFR could potentially provide for a clinically relevant improvement of KROM. Besides, during the experiment, changes of posture may have induced a soft-tissue tension effect, like the strain counterstrain technique as other studies have already demonstrated (Klein et al., 2013; Wong, 2012). However, our findings agree with many other investigations that describe the determinant collaboration of this approach on mobility gain and function in different musculoskeletal disorders (Ćosić et al., 2014; Day et al., 2009; Pratelli et al., 2015). Fascia's role in mobility has been progressively unveiled, and myofascial interventions pointed out as a substantial resource for manual therapists. Pratelli et al. (2015) proposed fascial manipulation for carpal tunnel syndrome. A total of 42 patients with confirmed clinical and electromyoneurographic diagnoses participated in the study and were divided into two groups: low-intensity laser therapy and fascial manipulation. The outcome was measured through recording pain levels and through use of a carpal tunnel syndrome functional questionnaire that, when analysed, revealed an improvement in pain and function. Although the approaches used are different, but with a similar purpose, their results are similar to the present study that also found a decrease in pain following treatment. However, 24 subjects (73%) did not report pain prior to receiving myofascial release; consequently, the results took into consideration the effect on eight individuals (24%). Besides, one patient described an increase of pain, which could be attributed to intolerance to prone positioning, sensibility to touch and stress level due to waiting for attendance.

According to sample characteristics, the pre-operative capsular pattern of the knee is a subject that needs further discussion. Despite the prolonged dysfunction of the knee before surgery, represented here by TKA waiting list time (4.53 years), the investigated superficial back line MFR can improve KROM. This MFR may be attributed to tensegrity's aspects (Ingber, 2008; Ingber et al., 2014; Schleip et al., 2012; Swanson, 2013). The release of superficial fascia is transferred to other connective tissue structures to establish a balance between tensile and compressive forces, possibly reaching the posterior capsule of the knee. Stecco et al. (2010) claim that movement dysfunction may be induced by modifications of connective tissue, which generate disarrangement of the surrounding fascia's structure, compromising the sliding system between its layers (Luomala et al., 2014). Additionally, the results may be influenced by the correlation between fascia and nerve endings (Gogola et al., 2014; Masi et al., 2010; Masi, 2014). Since it is constituted of dense connective tissue and highly innervated by autonomic fibres, the re-establishment of the sliding system of the fascia's layers may inhibit nociception (Stecco et al., 2010). The effect of the myofascial release on the peripheral nervous system will possibly be the next interest in future investigations involving pain and myofascial interventions. On the other hand, the myofascial meridians proposed by Myers needs to be evidence-based. Wilke et al. (2015) investigated articles from 1900 to 2014 to provide evidence of six myofascial meridians according to Myers' description: superficial back line, superficial front line, lateral line, spiral line, back functional line and front functional line. Analysis demonstrated moderate to strong evidence of the existence of the superficial back line. This aspect confirms our outcomes in pain and knee flexion contracture following TKA.

The results also pointed out an increase in electric activation of

Table 3
Knee Pain pre- and post-intervention. 2 patients presented no change in pain, whereas 1 reported that pain increased after treatment Knee Pain pre- and post-intervention.

	N	%	KPPA
No pain	22	66.67	0
Decreased pain	8	24.24	56.9
Other[a]	3	9.09	
Total	33	100%	

[a] 2 patients presented no change in pain, whereas 1 reported that pain increased after treatment.

biceps femoris muscle after myofascial release. A possible thixotropic effect over the extracellular matrix (ECM) of fascial tissue might be responsible for this variation. Nerve endings and blood vessels are embedded in the ECM and, therefore, are influenced by its viscoelasticity, altering the activation of fascia-related receptors (Klingler et al., 2014). Thus, the ECM of fascial interfaces between myotendinous structures, septa, superficial and deep fascia may undergo modifications after myofascial intervention. Stecco et al. (2013) affirms that the epimysium, perimysium and fascial septa are connected to muscle spindles through its capsule. Moreover, they state that many of those are directly inserted into the connective tissue, thereby confirming the intimate relationship between fascia and muscle spindles. In order for it to contract in response to gamma activation, it requires an elastic and adaptable perimysium. If the epimysium is too dense, it could resist the shortening of the muscle spindle, preventing the co-activation of the fibres associated with it. The authors also conclude that this mechanism may cause pain and interfere with the spindles' activations/deactivations, affecting movement coordination patterns. Therefore, by modifying the ECM's viscoelasticity through a myofascial intervention, the muscle spindle's barriers are minimised, leading to an improvement of muscle contraction, as the results of this study suggest.

Another aspect that elucidates the increase in muscle activity and the gain on mobility is hyaluronic acid (HA) (Matteini et al., 2009). This glycosaminoglycan is responsible for maintaining osmotic balance of the connective tissue's ECM while also reducing friction between fascial layers (Klingler et al., 2014). Special conditions, such as immobility, lead to an increase in HA concentration and, consequently, to the formation of complex chains of the polymer. This reduces the sliding system between fascial layers, increasing pain and limiting ROM. Tension forces generated by the myofascial intervention along connective tissue may affect HA chains, causing a thixotropic reaction in the ECM. Therefore, this study's findings suggest that KROM gain and muscle activation increment might be related to the reduction of HA's viscoelasticity. Following analysis of the data, the use of MFR on TKA rehabilitation is suggested, especially when limitations on KROM and scar tissue adhesion are present post-surgery. On the other hand, potential contraindications of MFR should be considered, for instance, lymphoedema, deep venous thrombosis and acute inflammatory processes such as cellulitis, due to the intensity of the technique.

4.1. Limitations

As a result of difficulties inherent to patients and the institutional routines, it was not possible to include a control group in this study. Hence, the influence of movements learning cannot be ruled out of the results, because the second assessment took place shortly after the first. Also, this study took place in a Brazilian federal hospital. The specific profile of patients that attend this institution may have underestimated the results. Patients waited a long time for surgery and as a result developed other complaints and limited function in the process, according to the institutional records. Furthermore, follow-up observations were not possible, because a lot of patients were residents in other counties and would initiate rehabilitation near home. In this study, it was not possible to determine how long the effect of the fascial release would continue for, since only the acute effect of MFR was addressed. Functional aspects of the outcomes were not measured, therefore the consequences of pain relief and KROM improvement on day to day life cannot be estimated. Moreover, psychosocial factors that might interfere with pain perception or collaborate to flexion contracture were not controlled.

Physiological effect of the myofascial intervention was not approached and resources that allow identification of the biochemical events following treatment were not applied. As such, it was not possible to identify other factors that could influence connective tissue's viscoelasticity, or collaborate to flexion contracture installation. The biochemical effects that allowed for patient improvement were not observed. Myofascial entrapments located above the experimental zone were not approached which may have underestimated the results. Since patients developed pain, atrophy and deformities while waiting for surgery, retentions throughout the myofascial chain distant from the lower limb could have possibly been installed. It should also be noted that most of the patients were moderately obese. The thick layer of fat beneath the skin associated with muscle atrophy represents a challenge to the application of the technique.

5. Conclusion

The myofascial intervention proposed in this study reduced knee pain and KROM and increased myoelectric activity of patients with flexion contracture of TKA patients with flexion contracture. Positive results were obtained despite limitations defined as capsular, which suggest this Anatomy Trains based treatment could contribute to stiffness improvement in TKA patients. Likewise, it could also represent an interesting tool to manual therapists.

Further studies, especially clinical trials or studies with a longitudinal design, are needed to better elucidate and outline the impact of Myerś́ myofascial intervention on pain, ROM, function and muscle contraction. They also should consider the integrity of myofascial chains, in order to control the repercussion of distant zones of the myofascial chain over the interested joint. Other resources such as elastography should be applied for identification of myofascial behaviour an after intervention.

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Conflict of interest

None.

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