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**The use of sonographically-guided botulinum toxin type A (Dysport) injection into
tensor fascia lata for the treatment of lateral patellofemoral overload syndrome (LPOS)**

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22 **Abstract:**

23 **Background:**

24 Pain in the anterior and lateral parts of the knee during exercise is a common clinical problem for
25 which current management strategies are often unsuccessful.

26 **Objective:**

27 To investigate the effect of an ultrasound-guided Botulinum Toxin (BT) injection into tensor fascia
28 lata (TFL) followed by physiotherapy in patients classified with lateral patellofemoral overload
29 syndrome (LPOS) who failed to respond to conventional treatment.

30 **Study Design:**

31 Case Series

32 **Methods:**

33 Forty-five patients (mean age: 32 ± 9 (mean $\pm$ SD)) who met inclusion criteria: 1. activity-related
34 anterolateral knee symptoms, 2. symptoms greater than 3 months, 3. pathology confirmed by
35 Magnetic Resonance Imaging, and 4. previous failed physiotherapy, underwent an ultrasound-guided
36 injection of BT into TFL followed by physiotherapy. Patient reported outcomes were collected at five
37 time intervals (pre-injection and 1, 4, 12 weeks and a mean 5 years post-injection). In 42 patients,
38 relative ITB length changes were assessed using modified Ober's test at the first four time points. A
39 computational model was run to simulate the effect of TFL weakening on gluteus medius (GMed)
40 activity. Statistical analysis was undertaken using a one-way ANOVA, and paired t-tests with
41 Bonferroni post hoc correction.

42 **Results:**

43 There was a significant improvement in AKPS scores from pre-injection (61 ± 15) to 1 (67 ± 15), 4
44 (70 ± 16), 12 weeks (76 ± 16) and in 87% of patients (39/45 patients available to follow-up) at
45 approximately 5 years from (62 ± 15.4) to (87 ± 12.5) post injection (All: $P<0.01$). A significant effect

on modified Ober's was identified as a result of the intervention with an increase in leg drop found at 1 ($3^{\circ}\pm 5^{\circ}$), 4 ($4^{\circ}\pm 5^{\circ}$) and 12 ($7^{\circ}\pm 6^{\circ}$) weeks post injection compared to pre-injection (All: $P<0.01$). Simulating a progressive reduction in TFL strength resulted in corresponding increases in GMed activity during gait.

Conclusion:

Injection of BT into TFL combined with physiotherapy resulted in a significant improvement of symptoms in LPOS patients, maintained at 5 years follow-up. This may result from reduced lateral TFL/ITB tension or to an increase in GMed activity in response to inhibition of TFL.

Clinical Relevance:

Findings support the use of combined BT injection and physiotherapy to successfully treat a newly defined sub-population of 'LPOS' patients.

What is known about the subject:

Patellofemoral pain (PFP) and iliotibial band syndrome are known to affect a large number of the young and active population. However current treatments are commonly unsuccessful in managing these conditions. The challenge of classifying these patients is recognised with terms including; 'patellofemoral pain', 'anterior knee pain' and 'chondromalacia patellae' commonly used to define the population. However the symptoms of these patients may vary widely and there is a recognised need to better define sub-populations of these patients. Ongoing symptoms have previously been reported in 80% of these patients at 5 years follow up. A prior study successfully treated a similar patient population, at up to 6 months follow-up, using an injection of BT into vastus lateralis.

What this study adds to existing knowledge:

Firstly this study defines a sub-population of patients who suffer activity-related anterolateral knee pain: we have termed this lateral patellofemoral overload syndrome (LPOS) and describe the features of this clinical presentation clearly. It is also the first study to present findings of BT injection into

TFL to treat this population, providing rationale for the potential beneficial effects of this intervention. We hypothesize these may occur as a result of TFL/ITB relaxation and/or increased gluteal recruitment. Furthermore the data includes long term follow up of results for over 5 years, which is valuable and rare in this patient population, given the chronicity of the condition, high activity levels, young age and frequent change of address.

Introduction

Superolateral fat pad (SLFP) impingement is known to occur at the lateral aspect of the patellofemoral joint (PFJ) and can trigger inflammation, causing subsequent fibrous hyperplasia and pain in the anterolateral region of the knee^{16, 17}. Iliotibial band syndrome (ITBS) meanwhile is typified by pain around the lateral knee during activity^{33, 41}, widely thought to result from compression of the fat layer between the iliotibial band (ITB) and lateral femoral condyle¹⁸. These pathologies are amongst some of the most frequent causes of knee pain seen by clinicians^{14, 46}, for which conventional interventions currently include: physiotherapy, orthotics, cortisone injections and surgery (commonly arthroscopy or lateral release). However such treatments often fail to deliver satisfactory results, particularly in the longer term^{3, 8, 30, 49}. Indeed at five years follow up, 80% of patients have reported ongoing symptoms, with 74% experiencing reduced activity levels¹⁰. Hence, there is a clear need for alternative interventions to help manage this complex patient group with longevity.

Investigations into these pathologies have primarily focussed on biomechanical differences between asymptomatic and symptomatic individuals including proximal (e.g. hip abductor weakness)²¹ and distal factors (e.g. increased navicular drop)³⁷. There is evidence suggesting that individuals with pain display excessive hip adduction and knee internal rotation during running^{20, 34, 39}, although, likely owing to limitations of measurement techniques and differences in participant demographics, these findings are not consistent^{5, 24}. The most common reason attributed to these undesirable kinematic differences is a lack of gluteal activation³⁸ or strength^{21, 32, 42}: a hypothesis supported by findings of improved symptoms in these patients following hip abductor/gluteal strengthening programmes^{15, 21}. Clinically, patients with weak gluteus medius (GMed) may compensate for weakness or inhibition by substituting with tensor fascia lata (TFL) recruitment. This dysfunctional firing pattern, which may be a source of chronic TFL tightness, is often identified in anterolateral knee pain patients²² although there is limited evidence to directly support this hypothesis at present.

The role of the iliotibial band (ITB) in this patient group has been widely examined. A modified Ober's test is commonly used to provide an indirect measure of ITB length, with high intra-rater ICC ($=0.91$) values reported⁴³. Using this test, it has been shown that ITBS patients have significantly tighter ITBs than pain-free controls^{26, 36}. Anatomically the ITB provides an insertion for the TFL and gluteus maximus (GMax) muscles proximally, with attachments to the femur, tibia and patella distally; it has an important role as a knee stabiliser and can influence patellar behaviour via its direct attachments^{29, 35}. Increased ITB tension during cadaveric testing was found to induce lateral patellar tilt and translation³⁵. Furthermore, shorter ITB length has been significantly correlated with lateral displacement of the patella²⁵, whilst patellar lateralisation during hip adduction was significantly greater in patients with tight ITBs²⁸. Elongation of the ITB / TFL complex is recognised to come primarily from the muscular component given the stiffness of ITB tissue: this could be via improved TFL flexibility or reduced recruitment^{2, 19}. Clinically, physiotherapy directed solely at strengthening hip musculature and stretching the ITB was 93% successful in these patients; compared to 0% success in the absence of these factors⁴⁷. This provides a strong case for the need to address TFL/ITB issues in this population. It is the authors' belief that these patients should be isolated from other patients with patellofemoral pain (PFP) and be selected for specific treatment based on their symptoms. In the present study a population of patients who suffer from Lateral Patellar Overload Syndrome (LPOS) are therefore defined. These are patients with activity-related symptoms, presenting with either one or a combination of superolateral fat pad impingement (SLFPI) and ITBS symptoms, identifiable on Magnetic Resonance Imaging (MRI). Critically the scans should be performed when patients are symptomatic (i.e. following a provocative activity such as running). Figure 1 shows MRI scans collected from the same athlete: a. following a period of rest and b. having run to provoke painful symptoms prior to the scan. Figure 2 shows both SLFPI and ITBS symptoms present on a scan, supporting the hypothesis that these conditions are not separate entities but are different manifestations of LPOS.

Recently, intra musculature injection of botulinum toxin type A (Dysport™) has been used successfully to reduce vastus lateralis (VL) activity and pain in a more general population of PFP

patients⁴⁵. Botulinum toxin (BT) produces inhibition of pre-synaptic acetylcholine release, causing a temporary (approx. 3 month) dose-dependent muscle inhibition⁴⁴. The present study investigates the short and long term effects of inducing temporary paralysis of TFL using a sonographically-guided injection of BT combined with a physiotherapy programme aimed at flexibility and strength: the measured outcomes were ITB length and patient reported outcome scores. Based on prior work it was hypothesised that BT injected to TFL would cause inhibition resulting in lengthening of the TFL/ITB complex and necessitating increased GMed recruitment, resulting in a reduction in symptoms. A cohort of patients displaying symptoms and signs of LPOS were the targeted population. Computational analysis based on an existing database was also undertaken to investigate the hypothesis that a reduction in TFL strength would result in increased GMed activity during gait.

Materials and Methods

Subjects and Study Design

Female and male patients aged between 20 and 50 attending specialised surgeon-led sports medicine clinics of the lead surgeon, were potential participants in the study. LPOS patients were selected based on history, clinical examination, special clinical tests (performed by the same experienced orthopaedic surgeon) and MRI. Patients were considered if they met all of the following inclusion criteria: 1. pain localised to the anterolateral aspect of the knee (lateral femoral condyle, distal and inferolateral to the patella), 2. activity-related symptoms (i.e. symptoms coming on with activities such as: running, jumping, ascending / descending stairs), 3. symptoms of greater than 3 month's duration, 4. pain could be reproduced by tensioning the ITB using a modified Ober's test 5. patients had undergone one or more failed course(s) of physiotherapy (consisting of best practice evidence based physiotherapy for this patient population, tailored to individual patient needs and including exercises to address gluteal, lower abdominals, quadriceps strength and flexibility as indicated) of at least six-weeks duration, and 6. confirmation of pathology (ITBS and / or SLFPI) based on an MRI scan taken directly following provocative activity. Patients were excluded from participation in the study if they had any of the following exclusion criteria: 1. patellar instability (subluxation or dislocation), 2.

patellar tendinopathy or 3. advanced patellofemoral osteoarthritis. The same experienced orthopaedic consultant reviewed all patient MRI scans to confirm the presence of SLFPI and / or ITBS. Study approval was obtained from the committee of Imperial College London.

Procedures

Patients received an ultrasound-guided injection of 75u of botulinum toxin type A (Dysport™, Ipsen) in 0.75ml of normal saline into the centre of the TFL muscle belly by an experienced musculoskeletal radiologist. Patients then underwent assessment and rehabilitation with an experienced physiotherapist. This consisted of a minimal 6 week course of physiotherapy, with prescribed exercise volume and subsequent progression determined according to the number an individual could perform correctly in a session, with patients seen for an average of 5 sessions. Rehabilitation was individualised to patient needs so a standard pathway was not followed. Patients typically worked on lower abdominal muscles and pelvic positioning following TFL inhibition. Gluteal exercises in a non-weight bearing and then weight bearing position were taught, single leg strength and control work was performed, alongside quadriceps strengthening and flexibility exercises as appropriate. Patients ran when symptom free and when the treating therapist was satisfied that gluteal strength was equal bilaterally and they had satisfactory single leg control. All these exercises, following a similar protocol and in line with patient needs, were performed during pre-injection physiotherapy as well.

Outcome Measures

Patient Reported Outcomes

The primary outcome measure was a change in self-reported knee pain using the Anterior Knee Pain Scale (AKPS; Kujala Score) before and after treatment³¹. This is a 13 item self-report knee-specific questionnaire, with a maximum score of 100. Lower marks are indicative of greater disability, and the scale has a reported minimal detectable change (MDC) of 7 points⁷. AKPS data was collected at five time intervals: pre-injection and then 1, 4, 12 weeks and a mean 5 years (5.6±1.1; mean±SD) following the intervention. At 5 years follow-up patients were also asked a further series of questions as shown in Table 1.

Modified Ober's Test

The length of the ITB was measured using a modified Ober's test, a commonly used test with high intra-rater ICC ($=0.91$) values⁴³. A MDC of 3.8° for this procedure is reported⁴⁰. Patients were placed in side lying with the examiner stood behind them, supporting the subjects' back and pelvis to prevent unwanted rotation during the test procedure. Patients flexed their lower leg fully and held onto it to stabilise the position (Figure 3). Their upper knee was then flexed to 90° , and upper hip flexed, abducted and then extended before the hip was progressively adducted whilst maintaining 90° of knee flexion until the limit of movement was reached or until unwanted pelvic rotation movements were induced. A spirit level was placed horizontally at the level of the posterior superior iliac spines (PSIS) and secured with tape; this was checked to ensure no lateral or anterior-posterior tilting of the pelvis occurred throughout the measurement procedure. A fluid inclinometer (ISOMED Bi-level inclinometer) was placed at a standardised position 5cm proximal to the lateral femoral epicondyle. The ITB length was measured in degrees, with a straight leg in a neutral position being recorded as 0° , more hip adduction was termed as $-^\circ$, with less adduction termed as $+^\circ$. All measurements were performed by the same experienced examiner. Readings documented from prior time points were not available for the examiner to view at subsequent follow up, to try to minimize any potential bias. Measurements were undertaken in 42 patients. Length changes of the ITB were recorded at four time intervals: pre-injection and then at 1, 4, and 12 weeks post-injection.

Computational Modelling

The hypothesis that TFL and GMed muscle activity are related (i.e. a reduction in one will result in an increase in the other), was investigated by using a well-recognised musculoskeletal model incorporating 76 muscles¹² and an example gait dataset for a normal subject²⁷, both of which are freely-available from the OpenSim website¹¹. This model calculates the optimum ratio of muscle forces during gait from the experimentally measured joint kinematic and ground reaction force data by minimising the sum of the muscle activity squared¹³. First, the model was used to calculate the muscle forces in the hip abductors (TFL and GMed) for the normal subject during the stance phase of gait. The effect of a BT injection was then modelled by reducing the TFL's maximum isometric force

by 25%, and then by 50% (i.e. the muscle strength was halved). The optimum muscle forces during single leg stance phase of gait (using the same gait input data) were recalculated for each of these models and the abductor muscle forces recorded. The effects of a dominant TFL muscle were also investigated by increasing the muscle's maximum isometric strength by 25 and 50%, recording the muscles forces for each case.

Analysis

Data were analysed in SPSS version 22 (IBM Corp, Armonk, New York). A Shapiro-Wilk test confirmed that the data sets were normally distributed. A power calculation based on prior AKPS change scores in a similar population⁴⁵ determined a sample size of 45 necessary to detect a significant change with 80% power and 95% confidence. To account for drop-outs during the study a sample of 55 was recruited.

To define the two parts of the study (short term and long term follow-up) two analysis procedures were undertaken. Initial pre, 1, 4 and 12 week AKPS and ITB data were analysed using a one-way ANOVA, comparing values obtained from the repeated measurements at different time points. Post-hoc paired t-tests with Bonferroni correction were applied when differences across test conditions were found. Paired t-tests were then used to compare pre-injection and long term follow up AKPS scores, from all the patients who were available for follow up at approximately 5 years. Data from patients who went on to have additional procedures following the initial BT injection were excluded prior to this analysis (n=7).

Results

Fifty-five patients were recruited to take part in the study and, accounting for failure to attend follow up appointments, forty-five patients (32.4±8.6; 17-50 (mean age±SD; range), n=31 females) completed the study, with 25=right sided knees. It was not possible to collect data on those patients who did not attend follow up appointments.

Patient Reported Short Term Outcomes (12 weeks)

Thirty six out of the forty five patients investigated reported improvement of greater than the MDC, representing 80% of the study population; the mean improvement from pre-injection to 12 weeks post-injection was 15 ± 12 (over twice the MDC of the score). Only three patient scores either did not change ($n=2$) or worsened ($n=1$), with a further six patients improving, but less than the MDC (mean= 2.5 ± 1). There was a significant improvement in scores identified from pre-injection (61 ± 15) compared to one (67 ± 15), four (70 ± 16) and twelve weeks (76 ± 16) post-injection ($P < 0.001$). Post-hoc tests identified a significant improvement in scores at both four weeks ($P = 0.02$, Mean Difference (MD)=9.8, 95% CI [1.0-18.6]) and twelve weeks ($P < 0.001$, (MD)=15.4, 95% CI [6.6-24.2]) post injection compared to pre-injection (Figure 4).

Modified Ober's Test

Thirty patients, 71%, had an increase in ITB length greater than the MDC at 12 weeks post-injection. A significant increase in hip adduction was recorded from pre-injection ($2^\circ \pm 9^\circ$; mean $\pm$ SD) compared to one ($-1^\circ \pm 7^\circ$), four ($-2^\circ \pm 8^\circ$) and twelve ($-4^\circ \pm 7^\circ$) weeks post-injection ($P = 0.004$). There was a significant difference, interpreted as a lengthening of the ITB, of $6.4^\circ \pm 6$ from pre-injection to twelve weeks post-injection ($P = 0.002$, MD = 6.5, 95% CI [1.8-11.2]) (Figure 5).

Computational Modelling

The simulated BT injection (decreasing the strength of the TFL by 25 and 50%) resulted in decreased muscular activity in the TFL, whereas a TFL that was stronger than normal (125% and 150%) served to incrementally increase its activity (Figure 6). It was also found that the model required increased activity in the GMed to compensate for decreased TFL strength and thus maintain the total hip abduction moment. Conversely the opposite was true when TFL was strengthened; the optimum balance of muscles forces required decreased GMed activity (Figure 7).

Long-term Follow Up

Thirty nine patients (87%) were able to be contacted at a mean of 5.6 ± 1.1 years (range: 4-6 years) following injection (Table 1). Four patients went on to have a further 1 or 2 BT injections following which their symptoms resolved, whilst two patients gained short term effects from the BT and went on to have a z-lengthening procedure to the distal ITB. A final patient later had a corticosteroid injection and physiotherapy following the BT injection.

Of the remaining 32 patients, 94% reported the injection helped their symptoms, with the same patients reporting they would repeat the injection if in the same position. Sixty nine percent of patients reported no pain in their knee, with the same number having returned to their pre-injury sports level. Repeat AKPS scores identified a significant improvement from (62.9 ± 15.4) to (87 ± 12.3) post-injection in the 32 patients who only had one BT injection ($P < 0.01$, MD=25, 95% CI [18.7-31.3]).

Adverse Reactions

Only two patients reported potential adverse responses to the BT injection. One described increased pain following intervention and the other reported an anxiety attack the day following the injection which the patient felt could have been related to the injection.

Discussion

This is the first study to report the successful long-term outcomes of BT injection to TFL combined with a physiotherapy programme for the treatment of LPOS. Sixty nine percent of patients reported complete resolution of symptoms at an average of 5 years follow up, far outlasting the expected duration of the drug. Significant increases in a modified Ober's test, suggestive of a lengthening of the TFL / ITB complex, were found in over 70% of patients. In addition the modelling results support the hypothesis that a reduction in TFL recruitment could instigate increased GMed activation. Although not measured directly, the findings offer two potential mechanisms for the positive effect of the BT: an effective lengthening of the ITB/TFL complex or an increased recruitment of GMed to compensate for the TFL inhibition. The paper also clearly defines what the authors believe to be a sub-population

of patients with anterolateral knee pain secondary to SLFPI and/or ITBS for whom this intervention offers both more sustained and superior outcomes to those previously reported⁴⁹.

There is presently a growing trend for the use of BT to aid rehabilitation to address muscle imbalance⁹. A prior study also found success in treating PFP patients with BT⁴⁵, with a similar aim to the present study; to reduce lateral patellar overload in patients. The patient population had delayed medial quadriceps activation, which improved with BT injection to the lateral quadriceps with effects largely sustained at 6-month follow-up. These findings combined with the present study support the use of BT as an adjunct to physiotherapy in carefully selected patients. There is debate regarding the existence of delayed VMO activation in this population⁶, with atrophy identified in all portions of the affected quadriceps in knees of patients with patellofemoral pathology, and no evidence of selective atrophy of the VMO relative to the VL identified²³. We believe this raises a question regarding the use of botox to inhibit VL. We therefore feel that injection into TFL may be preferential to inhibiting a possibly already weakened VL, but further studies would be required to confirm this.

Long term outcome (>1 year) studies of patients with PFP and ITBS in the literature are very limited⁴⁹. These results therefore provide valuable data to support the successful non-surgical management of these patients 5 years following intervention. In this study patients acted as their own controls, having all failed to improve with physiotherapy highlighting a greater benefit from combined physiotherapy and BT intervention than physiotherapy alone: at a mean of 5.7 years. A previous study showed that only 27% of patients were pain-free following physiotherapy alone³. The precise effect of the BT is not clear, however it appears to have either a lengthening effect on the TFL / ITB complex or an inhibition of TFL necessitating greater gluteal recruitment, which is known from prior work to positively impact this population⁴⁹. Indeed it may have an effect on both, with reduced TFL recruitment resulting in decreased muscle tone and thus an apparent lengthening effect on the TFL/ITB, with both effecting long-term changes.

The use of BT to manage muscle spasm in TFL has previously been found to reduce symptoms of persistent TFL tightness in patients following hip arthroplasty¹. In the present study the hypothesis of

a lengthening effect of the TFL/ITB complex resulting from the BT injection was supported in over 70% of patients. ITB shortening in this population, as previously discussed²⁶, may therefore be a significant factor in the perpetuation of symptoms. Greater ITB tensioning is known to affect patellar kinematics^{28, 35}, whilst it would also likely result in increased lateral femoral condyle compression, both potentially contributing to pain in this population¹⁸. However, the second hypothesis that a reduction in TFL recruitment increased GMed activation, was not possible to directly support with the clinical data. Thus we ran a computational model to quantitatively assess how strength changes in the TFL could affect the optimum recruitment strategy for these primary abductor muscles as they combine to balance bodyweight and stabilise the hip during single-leg-stance. We identified that with a progressive reduction in TFL strength there was a corresponding increase in GMed activity and vice versa. This quantitatively shows that for the same movement, there is flexibility in muscle recruitment: the amount of activity in the TFL could vary depending on a patient's muscular strength and recruitment strategy, something also identified in a dedicated modelling paper⁴⁸. LPOS patients are known to possess a lack of gluteal activation³⁸/strength^{21, 32, 42}, however it can be challenging for clinicians to teach these patients to recruit their gluteal muscles since they are adapted to compensate. A potential mechanism for the BT effect may therefore be that it forced patients to recruit their gluteal musculature, since they were no longer able to recruit their TFL, which has been recognised as a compensation strategy in this population²². Thus BT could be used as an adjunct to physiotherapy to improve outcomes. However, further clinical investigations are necessary to confirm these findings.

Study limitations include the specific inclusion / exclusion criteria, which mean that this sample is not broadly representative of all patients with PFP or ITBS. However, this is also an advantage since it is the first time this specific sub-population of patients has been defined in the literature, with a successful management strategy defined⁴⁹. A greater number of female compared to male subjects were examined; PFP is thought to more commonly affect females, so this may be representative⁴. Initial recruitment and diagnosis are important to standardise and therefore all patients were examined and enrolled by the same orthopaedic surgeon, but this could be a limitation. Physiotherapy administered was in line with best practice guidelines to manage strength and flexibility issues

identified by experienced physiotherapists treating these patients. However, precise exercise / dosage was not standardised; rather it was dependent on patient requirements / ability. This could be seen as an advantage since the non-standardised protocol means that the only common factor across all patients was the injection. The computational data was based on kinematic and kinetic data gathered from a bank stored in OpenSim and was not specific to LPOS patients. Therefore, this data has only been used to support the study hypothesis rather than for formal analysis. Furthermore we have no current understanding of the proportion of inhibition resulting from the BT injection to TFL, nor is it clear if LPOS patients have an overly-developed TFL, although their symptoms suggest hyperactivity and an over-dependence on the muscle. Therefore a range of presentations (50%-150%) were modelled to demonstrate the possible effects of increased/decreased TFL strength. Future studies could attempt to quantify this and repeat the analysis with data gathered directly from this patient group to enhance results.

Based on these findings the use of BT into TFL to supplement evidence based physiotherapy intervention in a clearly defined population of LPOS patients can be supported to reduce pain and improve function at over 5 years following injection. Although the precise mechanism of this improvement is not clear, we hypothesize based on our clinical and computational data that this was a result of a lengthening of the ITB/TFL complex and / or an inhibition of TFL resulting in an increase in gluteal muscle recruitment. We believe that the latter is the more likely the cause, possibly effecting a change in motor control which is reason for this to be maintained by patients' long term. Both of these mechanisms require further investigation in the clinical setting. Importantly this study clearly defined a population of patients with anterolateral knee pain, termed Lateral Patellar Overload Syndrome, which responded to this intervention and BT was not administered to all patients presenting with PFP, rather a sub-population of these. Botulinum Toxin as an adjunct to physiotherapy in appropriate populations represents a cost-effective, safe and reversible treatment and offers an attractive alternative in the management of this challenging patient group who often have unpredictable outcomes to surgical intervention.

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Figure 2: Axial fat saturated proton density weighted MRI scan demonstrating inflammation in both the superolateral infrapatellar fat pad (yellow arrow) and iliotibial band bursa (red arrow).

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Figure 6: Muscle force of the **TFL** muscle (normalised to subject body weight), and its values once it has been strengthened to 150% and weakened to 50%, during the single leg stance phase of gait: 18%-51%.

Figure 7: Muscle force of the **GMed** muscle (normalised to subject body weight), and its values when the TFL has been strengthened to 150% and weakened to 50%, during the single leg stance phase of gait: 18%-51%.

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571 **Table 1:** Responses of patients to follow up questions asked after mean 5 years following BT
 572 injection.

Long-term (5.6±1.1 years) follow up telephone questions	Yes	No
Did you suffer from any adverse effects as a result of receiving the BT injection (n=39)?	2	37
Have you had any other treatment for your knee pain since the injection (n=39)?	7	32
Do you still have pain in your knee (n=32)?	10	22
Did the BT injection help with your knee symptoms (n=32)?	30	2
Would you have the BT injection again if you were in the same situation (n=32)?	30	2
Did you return to your pre-injury activity level (n=32)?	22	10

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