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ORIGINAL RESEARCH ARTICLE

Regenerative Injection of Elite Athletes with Career-Altering Chronic Groin Pain Who Fail Conservative Treatment

A Consecutive Case Series

ABSTRACT

Topol GA, Reeves KD: Regenerative injection of elite athletes with career-altering chronic groin pain who fail conservative treatment: a consecutive case series. Am J Phys Med Rehabil 2008;87;890–902.

Objective: To obtain multisport and long-term outcome data from the use of regenerative injection therapy on career-threatened athletes.

Design: Consecutive enrollment of elite performance-limited athletes with chronic groin/abdominal pain who failed a conservative treatment trial. The treatment consisted of monthly injections of 12.5% dextrose in 0.5% lidocaine in abdominal and adductor attachments on the pubis. Injection of the nociceptive source was confirmed by repetition of resistive testing 5 mins after injection.

Results: Seventy-five athletes were enrolled. Seventy-two athletes (39 rugby, 29 soccer, and 4 other) completed the minimum two-treatment protocol. Their data revealed a mean groin pain history of 11 (3–60) mos. Average number of treatments received was 3 (1–6). Individual paired *t* tests for Visual Analog Scale (VAS) of pain with sport (VAS Pain) and Nirschl pain phase scale measured at 0 and an average of 26 (6–73) mos indicated VAS Pain improvement of 82% ($P < 10^{-10}$) and Nirschl pain phase scale improvement of 78% ($P < 10^{-10}$). Six athletes did not improve following regenerative injection therapy treatment, and the remaining 66 returned to unrestricted sport. Return to unrestricted sport occurred in an average of 3 (1–5) mos.

Conclusions: Athletes returned to full elite-level performance in a timely and sustainable manner after regenerative injection therapy using dextrose.

Key Words: Growth Substances, Osteitis Pubis, Glucose, Tendonitis, Groin, Proliferating, Tendons, Sports Medicine, Athletic Injuries, Sports Hernia

Groin pain is a very common problem in athletes, with 10–18% of male soccer players experiencing groin pain in any given year.[1] There is no consensus in the literature regarding definitions or diagnostic criteria for groin pain in athletes.[2] However, a recent clinical study reported results of systematic clinical assessments on 207 athletes with long-standing groin pain using reproducible examination methods. These methods emphasized resistive testing for pain imitation and revealed multiple causes in 33% of patients with adductor-related dysfunction in 60.9%, iliopsoas-related dysfunction in 59.7%, and abdominal muscle attachment-related dysfunction in 10%. Infrequent clinical findings included sports hernia in 1.9%, sacrotuberal ligament pain in 3.9%, hip pathology in 1.5%, and various other causes with less than 1% prevalence such as snapping iliopsoas, pelvic floor-related pain, sacroiliac dysfunction, hernia, piriformis-related pain, and stress fracture.[3] The ability to follow clinical results of treatment by resistive testing was confirmed by Verrall et al.[4] Our study was directed toward localization of attachment-related dysfunction by resistance testing and treating the proposed pathology in the attachment (connective tissue degeneration/insufficiency) by regenerative injection therapy (RIT) in a manner used in a previous small consecutive case series.[5]

Tendons may be subjected to unpredictable mechanical loads as they transmit forces to bone during high-level athletic activity. Similarly, ligaments are unpredictably stressed as they attempt to hold bony structures together at a fixed length. These mechanical loads, when excessive, lead to unhealthy changes in tendon or ligament structures. Numerous terms have been used to describe these unhealthy changes. Tendinopathy or tendinosis are terms commonly used to describe the actual pathology, which is primarily degenerative.[6] Because of the heavy use of adductors and abdominals by elite athletes, inhibition of performance due to pain from degenerative change can be career-threatening. RIT, otherwise known as prolotherapy, is a treatment technique that involves the injection of growth factors or growth factor production stimulants to promote growth and repair of normal cells and tissue; this has the potential to reverse degenerative changes.

Dextrose (glucose diluted in water) was chosen as the solution in this study because of expanding basic science and clinical evidence for its use in RIT.[7,8] Tissue elevation of glucose will not occur from oral glucose administration because of prompt insulin reaction. Thus, oral glucose can be used as a placebo intervention in nondiabetic patients. However, injection of glucose bypasses the insulin mechanism and immediately raises tissue glucose levels above that of normal cellular levels of 0.1%. Cells typically produce some or all of the polypeptide growth factors responsible for stimulating their own repair or replication via surface receptor site activation. Human cell (including fibroblast) exposure to dextrose (glucose) in as little as a 0.6% concentration stimulates prompt DNA activation for, and subsequent production of, platelet-derived growth factor, transforming growth factor-β, epidermal growth factor, basic fibroblast growth factor, insulin-like growth factor, and connective tissue growth factor.[9] These are the primary growth factors that work as a team to repair soft tissue (ligament, tendon, or cartilage) but not hard tissue (bone). Several current textbooks outline evidence-based research in this area in more detail.[7,8]

To reverse pathology in the area of cartilaginous junctions such as the symphysis–pubis and in the area of entheses, one would intend to affect both specialized connective tissue (cartilage) and linear connective tissue (tendon/ligament) that together must provide a competent interface for contractile tissue.

Dextrose safety and potential efficacy in preserving cartilage health has been demonstrated in both animal and human trials. Park et al.[10] demonstrated with saline injection control that 10% dextrose injection protects cartilage from breakdown in rabbits after transaction of their anterior cruciate ligament (ACL). Kim et al.[11] demonstrated that injection of either 10% dextrose or autologous serum, but not saline, led to tissue regeneration in artificially created "holes" in cartilage in rabbit knee. In humans, randomized controlled trials in knee[12] and finger[13] arthritis patients showed clinically and statistically significant benefit of dextrose injection over anesthetic alone.

In addition, safety and potential efficacy of dextrose in treating degenerative change of the connective tissue portion of the tendon/ligament interface with bone has been suggested by several recent studies. Injection of either 5% and 20% dextrose injection in the Achilles tendon of rats resulted in an increase in fibroblast number and fibroblast count, but saline injection of identical osmolarity did not cause any significant change.[14] Administration of nonsteroidal antiinflammatory drugs (NSAIDs) orally did not prevent proliferation effects of 20% dextrose upon injection of the Achilles equivalent tendon in rats, suggesting that the proliferation effects of dextrose are not owing to inflammatory mechanisms alone.[15] In humans, the ability of intraarticular injection of dextrose to tighten loose ACL ligaments and to eliminate pain and laxity symptoms in the human knee has also been demonstrated by an initial long-term study of patients with machine-measured ACL laxity with 3-yr follow-up.[16] Maxwell et al.,[17] using high-reso-

lution ultrasound to follow up on patients with Achilles tendon strain injected with 25% dextrose (intratendinous), demonstrated clinical improvements and concomitant improvements in the structure of the Achilles. These sonographically demonstrable improvements included an improvement (reduction) in mean tendon thickness, reduction in anechoic clefts or foci, and an improvement (decrease) in neovascularity.

Use of standardized examination methods to determine areas of injection would allow for a reproducible technique. Hölmich et al.[2] demonstrated that "functional testing" of athletes with chronic groin pain by contraction of muscles against resistance to determine their potential involvement as a pain source in chronic groin pain seems to have good intra- and interexaminer reliability. We reasoned that if contraction against resistance can identify a nociceptive source preinjection, then contraction against resistance can also be used after injection of an anesthetic containing solution to confirm that all nociceptive sources were infiltrated. Using resistance testing methods similar to those proposed by Hölmich[3] and Verrall et al.,[4] 24 consecutive elite (primarily rugby) athletes with chronic groin pain preventing top level play were treated by RIT with 12.5% dextrose in 0.5% lidocaine.[5] Data capture was 100% in that study with no dropouts, and 22 of 24 athletes reached and sustained unrestricted play, with 21 athletes pain-free at a mean of 17 (6–32) mos follow-up.

Proceeding directly to a randomized controlled trial at that time was not feasible because of recruitment limitations for an injection method that had not yet shown multisport applicability or long-term durability in chronic groin pain. In addition, athletes already truly chronic are not easily persuaded to postpone return to play for months longer for a "control" treatment; there is, of course, no proprietary interest in support of a study using dextrose. We reasoned that expanding (tripling) the size of our previous consecutive patient trial would offer substantial evidence of efficacy of RIT in the groin pain population by several methods. The larger study size would add more power to the observations, and continued follow-up on previous study athletes would add information on durability of benefit. We hoped that publication of our initial data on almost exclusively rugby players would facilitate recruitment of more soccer athletes to determine the efficacy of RIT in multiple sports. Therefore, our decision was to continue consecutive athlete enrollment to the point at which our original study size was tripled.

MATERIALS AND METHODS

Rationale for Solution Used (12.5% Dextrose in 0.5% Lidocaine)

For the treatment of athletes described here, we chose to use 12.5% dextrose, which is mildly inflammatory, because that is the most common concentration used in the clinical practice of regenerative injection. The dextrose solution also included 0.5% lidocaine to allow for examination after anesthesia of the structure. If complete elimination of groin pain resulted from injection of 0.5% lidocaine, this helped exclude rare causes of groin pain not associated with attachment issues.

Study Inclusion Requirements

Figure 1 illustrates the practical decision-making process on candidacy for treatment and the flow of athletes through the study. Athletes were required to be both "elite" and "impaired." For purposes of this study, elite athletes were identified as athletes engaged in team competition against

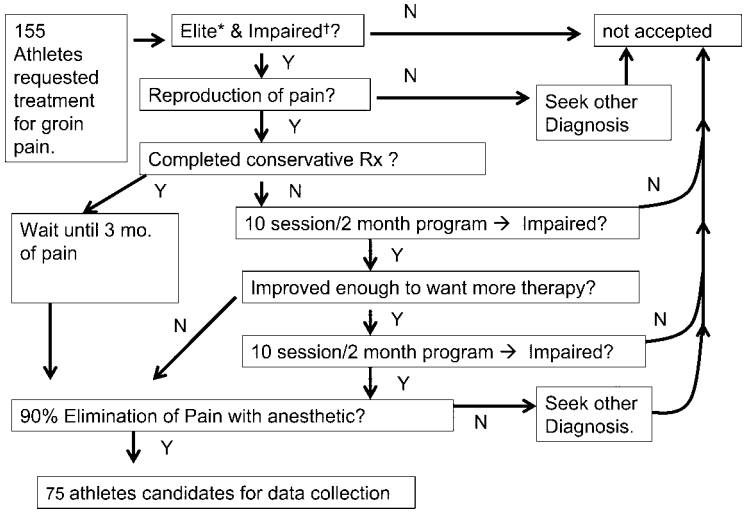

FIGURE 1 *Confirming diagnosis and conservative treatment failure.*

TABLE 1 Nirschl pain phase scale of athletic overuse injuries

Phase	Pain Relation to Sport	Formal Description of Phase
0	No soreness	No stiffness or soreness after activity
1	Sore after play for <24 hrs	Stiffness or mild soreness after activity; pain is usually gone within 24 hrs
2	Sore after play for <48 hrs	Stiffness or mild soreness before activity that is relieved by warm-up; symptoms are not present during activity, but return afterward, lasting up to 48 hrs
3	Sore during play, but no play alteration	Stiffness or mild soreness before specific sport or occupational activity; pain is partially relieved by warm-up; it is minimally present during activity but does not cause the athlete to alter activity
4	Sore during play, including play alteration	Similar to phase 3 pain but more intense, causing the athlete to alter performance of the activity; mild pain occurs with activities of daily living but does not cause a major change in them
5	Sore during other activities	Significant (moderate or greater) pain before, during, and after activity, causing alteration of activity; pain occurs with activities of daily living but does not cause a major change in them
6	Constant pain	Pain that persists even with complete rest; pain disrupts simple activities of daily living and prohibits doing household chores
7	Sleep disturbed	Pain that also disrupts sleep consistently; pain is aching in nature and intensifies with activity

teams from other cities, provinces, or nations. The qualification of impairment was a phase 4 or higher self-rating on the Nirschl Pain Phase Scale (NPPS) of Athletic Overuse Injuries (Table 1).[18] Phase 4 is reached when pain is intense enough that the athlete cannot perform at top level. If these two requirements were met, reproduction of the athlete's pain was required by palpation of the pelvic rim and/or ischiopubic ramus with abdominal or thigh adductor contraction against manual resistance by the examiner. Resistance to abdominals was accomplished by placing the examiner's hand on the athlete's chest during a partial knee-bent sit-up. Resistance to the thigh adductors was performed in four positions of the hip (flexed in neutral, internal and external rotation, and extended in neutral rotation) against the fixed length of the examiner's forearm between elbow and wrist between the athlete's legs. Athletes whose pain was not imitated were advised to seek another diagnosis.

Attention then was directed at whether these athletes had met the requirements for a conservative therapy course (Table 2). This consisted of a minimum of 1 mo of rest from running or jogging with core strengthening and stretching, followed by a minimum of 1 mo of graded activity reintroduction. Those athletes who had not previously received such an approach were enrolled in a 2-mo program following the pattern listed in Table 2. After completion of the 2-mo period, athletes that

TABLE 2 Minimum therapy requirements before enrollment

	Duration	Required Components/Description
Relative rest	1 mo	No running or jogging Lumbopelvic muscle stabilization including adductors, abductors, lumbar, gluteii, and quads and lumbar spine using pilates, swiss ball, or on mat; exercises performed to slight discomfort level only Stretching of hamstrings and iliopsoas and pyramidalis
Sport reintroduction	1 mo, after above	Weekly progression to slow jogging, faster jogging, running, and running and kicking as pain-free with only mild postactivity soreness that clears overnight
Modalities	Not required	Not required but most had received deep-tissue massage; modality use was not emphasized in therapy ordered for patients that had not received it before inquiry

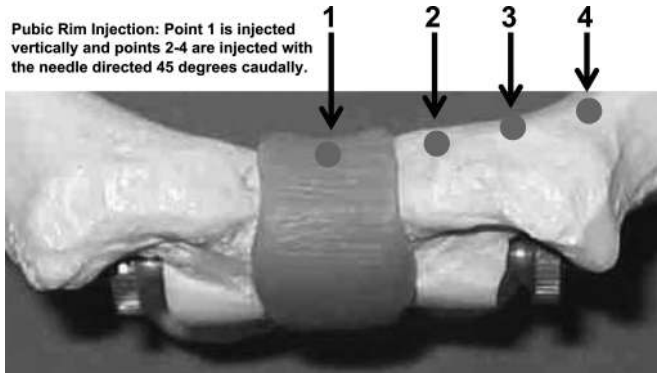

FIGURE 2 *Injection of symphysis pubis and the superior pelvic rim.*

felt they had benefited and had made some functional progress toward full play were offered another 2-mo program. If athletes were no longer impaired after therapy, they were not accepted into the study. If pain levels were such that the patient in their own opinion was still unable to perform at a high level in their sport, they were then enrolled in the study. Thus, 75 athletes were offered a first injection session. We expected that despite local anesthetic injection, there might be some mild peripheral soreness from other tissues pressured via palpation or resistance. We, therefore, picked a number that should represent both to the patient and ourselves that the pain was either eliminated or virtually eliminated (90%). Therefore, after the injection, patients were asked if their pain was reduced 90% or more. If they said no, they were to be advised to seek another diagnosis. If they said yes, we considered that sufficient to indicate that the nociceptive sources were adequately treated. All athletes stated their pain relief was 90% or more, so none were advised to seek other diagnoses. Just before the first injection, a baseline Visual Analog Scale (VAS) for pain with sport and NPPS were obtained.

Treatment Method

If the patient had pain over the pelvic rim with resisted contraction of the abdominals, the pelvic rim was palpated during contraction and marked by areas of pain during muscular contraction. If the patient had pain over the ischiopubic ramus or symphysis pubis with resisted contraction of the adductors, the symphysis pubis and ischiopubic ramus were marked in similar manner during muscular contraction. If pain on only one side was noted with resisted contraction, only that side received injections. This process was followed at each visit as the area of injection generally decreased. Overlying hair and skin areas were prepared with liberal use of povidone iodine. The solution used was 12.5% dextrose and 0.5% preservative-free lidocaine (25% dextrose mixed 1–1 with 1% lidocaine). About 1 ml of solution was first injected at a 90-degree angle to the skin surface into the symphysis pubis (Fig. 2). Needle insertions were then made at 1-cm intervals along a horizontal line 2 cm rostral to the palpated top of the pelvic crest, injecting 1 ml of solution in each location. Needle insertion was at a 45-degree angle heading caudally. For each injection, the top of the iliac crest was lightly contacted by the needle. The needle was then walked off the superior border of the pubic crest and then repositioned on top of the pubic crest. To inject the ischiopubic ramus (Fig. 3), needle entry followed a line 3 cm lateral to the midline. For the first injection (labeled "5"), the insertion was parallel with the long axis of the body. Then, three additional spots were injected with medial needle direction as needed to contact bone at approximately the same depth. Medial orientation, used as needed, avoids potential contact with either foraminal structures or midline structures. Listed comprehensively, attachments that could reasonably be affected by solution spread by the combination of pubic rim and ischiopubic ramus injection would include the conjoined tendon (combined tendons of internal oblique and transversus abdominis), pectineus, pyramidalis, external oblique, rectus abdominis on the superior pubic rim, adductor magnus, gracilis, adductor brevis, adductor longus, and rectus abdominis.

Five minutes after injection, patients were checked to ensure that isometric contraction of the abdominals and stretching or isometric contractions of the adductors were pain free; if not, additional solution was infiltrated.

Posttreatment Follow-up

Athletes were asked not to seek any treatment other than study treatment for a minimum of 3 mos after receiving the first injection. The posttreatment activity plan (Table 3) after the first injection session involved no exercise and walking

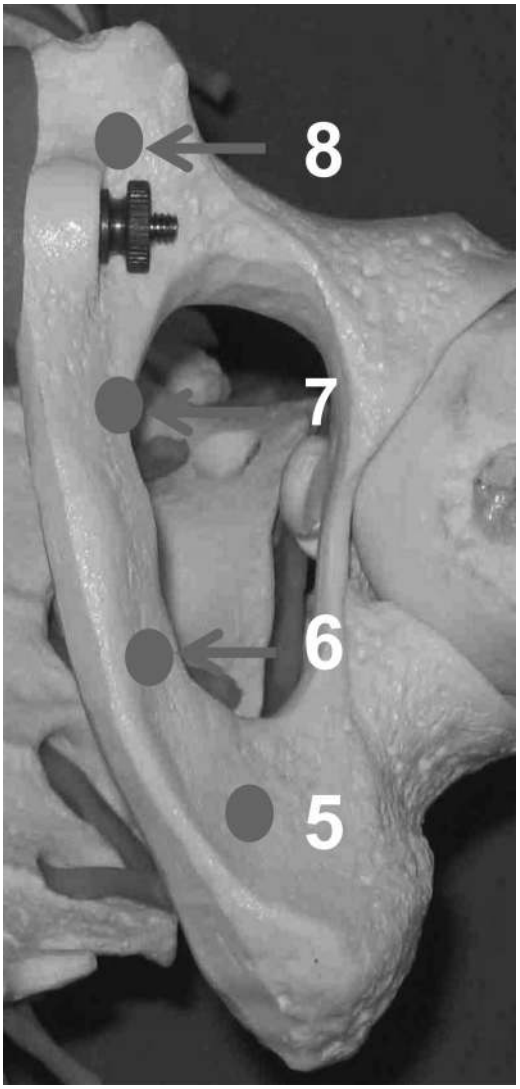

FIGURE 3 *Injection of the right ischiopubic ramus. Insertions are made about 3 cm from midline, parallel with the longitudinal axis of the body for point 5 and heading somewhat medially as needed to touch bone for points 6–8.*

only for 1 wk, then progression as described. After the second and subsequent injection sessions, the athlete was advised not to run or kick for 3 days instead of 7. Compliance was fairly well controlled via observation with players in the rugby union, but observation of soccer athlete compliance was not feasible, because soccer athletes and connections with coaching staffs were not as close. The key guideline was a lack of discomfort with activity, minimal discomfort after activity, and avoidance of NSAIDs; this was to avoid blunting healing, or even an awareness of discomfort.[19]

Data Collection

Athlete data were to be gathered until the study size increased by 200%, as determined by the 72 patients reaching the point of second data point collection (Fig. 4). Athletes reached the point of second data point collection if they failed to improve after a minimum of two treatments and did not get back to sport. If they did get back to full sport, they qualified for data collection if no pain was noted or if minimal pain was noted and the patient either desired to stop or had no further improvement for two treatments. Posttreatment data integrity was preserved by periodic re-contact of athletes treated to keep their contact information current, but the actual posttreatment data point was obtained by meticulously contacting all athletes for their status at the point that the last of the 72 patients reached 6 mos after the point of plateau (third data point in Fig. 4). Thus, the posttreatment follow-up data point would vary from 6 mos for the last enrollee to a number of years for the first enrollee.

This research was approved by the Institutional Review Committee (Science and Research Committee) of the Provincial Hospital of Rosario, Argentina, and was conducted in accordance with the Declaration of the World Medical Association. The statistical analysis software used was the SPSS (Statistical Program for Social Science, version 15.0).

RESULTS

Of these 75 athletes, 3 failed to wait 3 mos before receiving other treatments (Fig. 4). One basketball player improved 40–60% but received surgery on the advice of his orthopedic surgeon. One soccer player received surgery on the advice of his trainer after one treatment. The third athlete, a soccer player, returned to unrestricted sport after two treatments but indicated at follow-up that he had also received osteopathy and steroid injection by other practitioners during the 3-mo period after the first injection, preventing ability to determine the reason for his success. Seventy-two athletes thus qualified for data analysis. This total included 55% (39) rugby athletes, 41% (29) soccer athletes, 2 professional basketball players, 1 professional hockey player, and 1 long-distance runner.

Data on All 72 Patients

Hotelling multivariate analysis of paired observations for data observed at 0 mo and 26 (6–73) mos postplateau demonstrated a statistically significant difference (Table 4) ($P < 10^{-10}$). Individual paired t tests showed improvement in VAS Pain of 82% ($P < 10^{-10}$) and in NPPS of 79% ($P < 10^{-10}$). Sixty-six of 72 athletes returned to full sport, and all but 2 of the 66 athletes did return to full sport pain free.

TABLE 3 After-treatment activity progression guidelines

	After First Treatment	After Second or Subsequent Treatment
Nonsteroidal antiinflammatory drug use	Avoid to allow accurate assessment of discomfort	Same
Activity progression guideline	Progress as noted below but only as no pain during and only mild soreness after activity	Wait 3 days and then resume at previous level
First week	No exercise; do normal self-care	
Second week	Adductor and abdominal gentle stretching Strengthening of adductors and abdominals at pain-free angles and pain-free force until back in sport for 1 mo; other exercises not required; jog as tolerated, starting at 5 mins per km but increase km and speed per guideline	
Third week	Run as tolerated, including full speed, but only in intervals; i.e., 100–200 m at a time	
Fourth week	Can practice with group and do exercises with the ball; begin kicking as comfortable	

Data by Sport

Table 4 also lists data analyzed by sport. The numbers of pro basketball (2), hockey (1), and long-distance runners (1) were too few for comparison. The rugby players were under the supervision of both an orthopedic surgeon and physiatrist involved in the study so the posttreatment restrictions were easily enforced. Compliance of athletes other than rugby to posttreatment limitations could not be monitored at the same level. The 39 rugby players appeared to fare somewhat better than the 29 soccer players with VAS Pain improvements in rugby and soccer players of 88% and 76%, respectively, and NPPS improvements in rugby and soccer players of 86% and 74%, respectively. However, Hotelling multivariate analysis of paired observations by sport (rugby and soccer) revealed no significant difference between sport for data observed at 0 mo and 26 (6–73) mos follow-up ($P = 0.209$).

The six athletes who were nonresponders included four soccer, one rugby, and one basketball player and were followed up for a minimum 6 (6–60) mos and received a minimum of two (2–5) treatments.

Postinjection soreness was common but minimal, lasting typically for several days. No other untoward effects were noted. The areas treated simplified with treatment, with one side often becoming asymptomatic on resistance testing after one to two treatments.

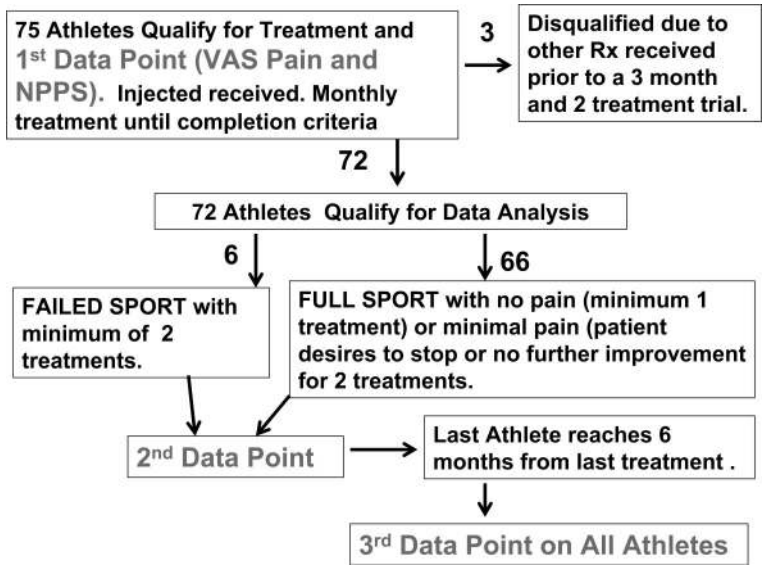

FIGURE 4 *Collection of pre-, post-, and long-term follow-up data points.*

TABLE 4 Changes in Nirschl Pain Phase Scale (NPPS) and Visual Analog Scale (VAS) pain in all athletes and in rugby and soccer athletes

Group and Variable	No. Athletes	Mean and (SD) 0 mos	Mean and (SD) 26 (6–73) mos	Mean Difference 0–26 mos	Standard Error of Mean Difference	95% CI for the Mean Difference	Significance Between Means at 0 and 26 mos
All sport NPPS	72	5.13 (0.47)	1.06 (1.58)	4.07	0.18	3.71–4.43	$<1/10^{-10}$
All sport VAS pain	72	6.47 (1.59)	1.18 (1.89)	5.29	0.27	4.75–5.84	$<1/10^{-10}$
Rugby NPPS	39	5.21 (0.57)	0.74 (1.33)	4.47	0.20	4.27–4.67	$<1/10^{-10}$
Rugby VAS pain	39	6.44 (1.55)	0.79 (1.47)	5.65	0.34	5.31–5.99	$<1/10^{-10}$
Soccer NPPS	29	5.00 (0.27)	1.31 (1.75)	3.69	0.31	3.38–4.00	$<1/10^{-10}$
Soccer VAS pain	29	6.28 (1.44)	1.48 (2.23)	4.80	0.42	4.38–5.22	$<1/10^{-10}$

CI, Confidence interval.

Table 5 shows the athletes grouped by the pattern of injection required. Notable is that abdominal involvement was seldom present without adductor involvement. Also notable is that the adductors were involved without the symphysis pubis in 14 of the 72 patients. A *t* test of independent samples comparing rugby and soccer athletes showed no significant differences in attachment pattern involvement between sports.

Durability of treatment is illustrated by Figure 5. This figure shows the average values for VAS for pain and NPPS at start of treatment, at plateau when treatment was stopped, and 26 (6–73) mos after the last treatment. All athletes that reached full sport ability by plateau maintained full sport ability, although a few (2/66) developed some pain with sport that did not alter their sport. It is notable (not depicted) that only 3/66 athletes who returned to full sport needed any further treatment after plateau (1–2 treatments per athlete), despite the vigorous nature of their activity. Two were rugby players, followed for 70 and 41 mos, respectively, and one was a long-distance runner.

The efficiency of treatment is indicated in Figure 6. This illustrates the number of treatments that athletes received to reach their plateau. This average number of treatments to reach plateau was 3.0 (1–6). Because the third treatment was given at 2 mos and follow-up was 1 mo later, the time to plateau would have been equivalent to the number of treatments or 3 (1–6) mos. Although the time of return to full sport was not precisely determined, all athletes returned to full sport before reaching plateau, so that the mean time for return to sport would have been less than 3 mos.

Evaluating the effect of the presence of a partial avulsion of the adductor attachment was not a focus of the study because standard films were available for less than half the patients. Those six patients for whom a radiograph was available and that demonstrated an avulsion before treatment returned to unrestricted sport and sustained that status.

DISCUSSION

Three favorable aspects of the environment in Argentina contributed heavily to success in study completion. One was a high degree of collegiality between orthopedic and physiatric specialties in the Argentinian Rugby Union, which limited premature dropout at least in rugby athletes. The second favorable aspect is that athletes in Argentina have a relative lack of funds to fly about to see other specialists and, thus, are more likely to reliably follow study protocol. The third is that treatment is covered by the public health system in Argentina, enabling the primary author to treat patients with an inexpensive method without re-

TABLE 5 Patterns of treatment areas in 72 athletes

Areas Treated	Abdominals Symphysis Adductors	Abdominals Symphysis	Symphysis Adductors	Adductors
No. of athletes	47	4	7	14
No. returning to unrestricted sport	43	4	7	12

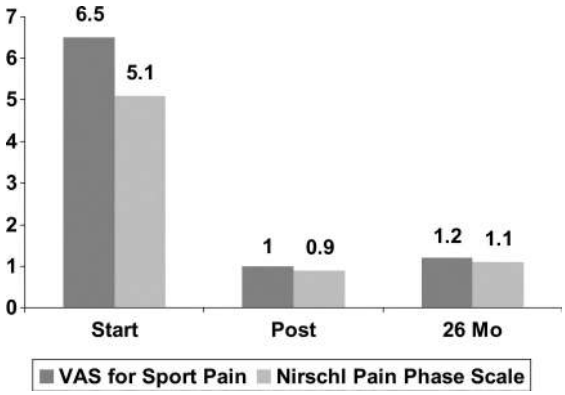

FIGURE 5 *Comparison of pretreatment, plateau, and medium or long-term data.*

imbursement other than that provided by the public health system.

Some may question the adequacy of our therapy trial, stating that perhaps a different form of exercise or stretching would have led to more potent results and less need for regenerative injection. As advances occur in our knowledge of groin pain and its biomechanics, more therapy successes can be anticipated. However, to take the position that our athletes were not truly therapy failures and thus could not serve as their own control is not reasonable. First, in the care of elite athletes, a longer treatment course than what we required is impractical. In addition, from a cost standpoint, a long therapy course is actually rather expensive and will place as much or more financial strain on both the athlete and the system. An extensive review of the therapy literature is not feasible here, but Verrall et al.[20] reported arguably the best published results from a conservative approach to groin pain in athletes. His approach used 12 wks of complete running avoidance, during which a meticulous approach to nonweight-bearing conditioning was taken, as well as gradual introduction of core strengthening. Then, running was slowly reintroduced. In Table 6 (column 1), his results are summarized. The size of the study was small, a number of patients were new to therapy (no previous treatment failure was required), and chronicity was marginal. Good results in pain reduction occurred in these athletes, but peak success in return to the same level of competition did not occur until the second season posttreatment onset (between 1 and 2 yrs). Although 81% of athletes were said to be pain free by that time, 26% of athletes were still not playing at the same level of competition and the number of athletes playing both at the same level of competition and fully unrestricted was not documented.

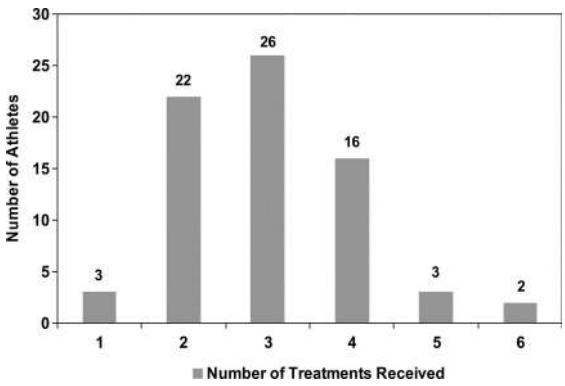

FIGURE 6 *Number of treatments received.*

The therapy course we requested (Table 2) was a minimum of 2 mos long and was repeated if improvement occurred. This did result in some return to unimpaired sport. This effort plus the chronicity of our patients increases the likelihood that a durable return to unimpaired sport was unlikely in the remaining athletes and that those athletes injected in our study can realistically be considered their own controls and "therapy failures." Despite a longer duration of pain and an already-demonstrated resistance to therapy, our success rate at return to full sport was substantially higher by 3 mos (92%) than by the second season of the therapy-alone approach (Table 6, column 2).

The argument for surgery in chronic groin pain (in short) is that a clinically undetectable deficiency of the posterior inguinal wall (transversalis fascia) and the conjoint tendon (common tendon of the transversus abdominals and internal oblique) is common and that this cannot be corrected with conservative measures. van Veen et al. in 2007[21] published a consecutive patient data collection on the use of endoscopic total extraperitoneal mesh placement. The outcome of that study is shown in Table 6, column 3. These patients were somewhat selected of course, with athletes required to have abdominal attachment pain. Fifty of 55 athletes returned to unrestricted play within 3 mos. The remaining five athletes did return to competitive play eventually as a result of additional treatment (two after repeat surgery for complications of the original surgery, and three after additional physical therapy.) Two of the initially successfully treated athletes later suffered adductor rupture on one side but were able to again return to full sport with time and rehabilitation. Thus, from the single surgical intervention, the return to unrestricted sport was 91% by 3 mos.

The injection method used in our study would be expected to affect the common tendon of insertion of the transversus abdominals and internal oblique that forms the posterior wall of the inguinal canal, as well as the external oblique and rectus abdominis insertion that forms the roof and floor of the inguinal canal. Injection of these areas either

TABLE 6 Representative type IV studies on exercise, RIT, and surgery

	Verrall (Therapy)	Topol (RIT)	Van Veen (Surgery/TEP)
Size	27	72	55
Subjects	All comers	All comers	Abd involvement required
Previous Rx failure	Not required	Required	Not documented
Pain duration	5 (2–11) mos	11 (3–60) mos	Min 3 mos; range unknown
Full sport	74% by 12–18 mos	92% by 3 mos	91% by 3 mos
Full level play	Not confirmed	92% by 3 mos	91% by 3 mos
Follow-up	2 yrs	Mean 26 (6–73) mos	2 yrs (not documented)

Complications weak tissue altered biomechanics. Career risk (failure) Career risk (delay) none 2 surgical complications. Two delayed ruptures.
TEP, total extraperitional.

eliminated the pain with active contraction or further injection was performed, further reinforcing the fact that the origin of pain (area of connective tissue insufficiency) was infiltrated with solution. A summary of our patterns of treatment (Table 5) reveals that we had 51 athletes with abdominal involvement confirmed by examination and injection, of which 47 returned to full sport, similar to the 50 of 55 full sport return reported by van Veen et al.[21] We submit that this indicates that regenerative injection can indeed provide a conservative alterative to surgery for insufficiency of the abdominal wall.

Biomechanically, it has been proposed that adductor tendinopathy is caused by pelvic instability together with weakness of the inquinal wall, so that tenotomy of the adductor should only be proposed for persistent pain in the groin after endoscopic total extraperitoneal mesh placement or for tendocalcinosis seen on ultrasonography.[21] Upon reexamination of our data, it is notable that 14 patients had pain only on the adductor insertion. These were injected only on the adductor insertion and showed complete relief of pain with contraction. This implies that at least in some athletes, the adductors are an issue of importance as a primary etiology of groin and are not merely reactive to pelvic instability.

Some have suggested that diagnostic imaging plays a "crucial role" in reaching the correct diagnosis in chronic groin pain.[22] However, Figure 7 describes how history, coupled with examination, response to anesthetic injection, and response to treatment, can reduce the need for other diagnostics. The chronicity of abdominal pain or groin pain and absence of urinary symptoms rule out many disorders, as does the absence of pain with weight bearing, snapping hip, or systemic symp-

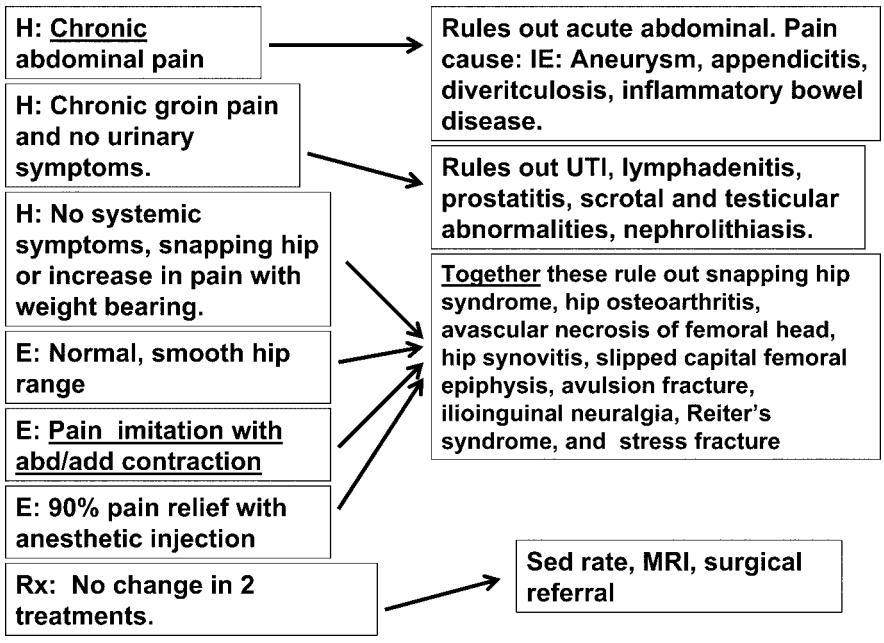

FIGURE 7 *Differential diagnosis via history, examination, and treatment.*

toms. Major examination contributions to ruling out other significant conditions include imitation of pain with resisted muscle contraction and its elimination with anesthetic injection. Noted is that these maneuvers cannot rule out the presence of low-grade alternative pathology, but they imply that the key nociceptor is connective tissue-based and is reachable with the anesthetic injection. Because clinical improvements occurred promptly in our patients, it seems reasonable when using regenerative injection to defer extensive radiographic diagnostics until the initial clinical response is noted. The position that radiographic imaging should not guide treatment is reinforced by a strong correlation between resistive testing and magnetic resonance imaging abnormalities[4] and from practical observations that preseason clinical groin pain is a much better indication of likelihood of missed games than bone marrow edema or parasymphyseal T2 hyperintensity on magnetic resonance imaging.[23]

Acetabular labral tears are stated to be a common cause of groin pain, found potentially in 20% or more of athletes presenting with groin pain.[24] The presence of labral tears would be expected to limit results in our study as well. The presence of a "click in the hip" is 100% sensitive but not 100% specific. No patients with a click were treated in this study. However, for those athletes with a minor nonpainful click it may be best to treat pubic bone pain imitated by resistive testing for two to three sessions and then explore labral tear significance if groin pain persists after regenerative injection.

The literature on conservative treatment describes treating three primary muscle groups (adductors, iliopsoas, and abdominals) involved in patients with chronic groin pain.[3] We did not treat the iliopsoas in this study other than checking for tightness and giving stretching exercises before enrollment. Given the good clinical response we attained, this raises the possibility that the iliopsoas pain and dysfunction is largely reactive rather than representing primary pathology in the athlete with chronic groin pain.

We have been asked about patients that had an avulsion of the adductor tendons and how they responded to treatment. We did not routinely obtain radiographs on all patients in this study. However, seven of seven athletes with avulsion of bone from the adductor insertion on the ischiopubic ramus responded to treatment to the point of unrestricted sport. The concept of treatment of adductor pain surgically has included in some cases partial incisions to "cut the offending fibers" to decrease stress on the bone.[25] Thus, there is no reason to suggest that the presence of a partial avulsion would serve to impede benefit from regenerative injection on the remainder of attached fibers. A potential advantage of regenerative injection over "release" of an offending portion of a tendon is the ability by injection to strengthen the tendon insufficiency area rather than cutting it, because the latter can expose the athlete to rupture later.

To sports medicine physiatrists, the ability to return athletes to their sport promptly and efficiently, with little risk, is paramount. Conservative treatment would seem the safest to a casual observer, and thus, a conservative treatment approach off season is the current standard of care. However, the risks to the athlete of a conservative approach beyond a few months (Table 6) include a heightened risk of reinjury due to incompletely healed degeneration, risk of injury to other areas of the body via altered biomechanics of play, and risk to their career through limited success and slow symptomatic improvement. The potential uses for regenerative injection in the athlete with groin pain are substantial. One would be to return the impaired athlete to unrestricted sport at approximately the same speed as a surgical approach. A second potential use would be to treat the minimally symptomatic patient during the season with a gentle proliferant to prophylaxe against rupture. The athlete who does not respond to injection, despite pain relief with anesthesia, would likely be an ideal surgical candidate. One disadvantage of injection is discomfort, which can be addressed with procedural sedation if necessary. However, in this study, injections were feasible without sedation in this highly motivated group of elite athletes. Another disadvantage is potential infection or allergy, as with any injection, but with proper skin antiseptic preparation of the site, this is rare.

CONCLUSION

In many conditions seen by the sports medicine physician, treatment options including surgery, complicated therapy courses, and injection therapies are primarily researched by level IV study methods. The athletes in this study can truly be said to be their own control because of several factors. These include confirming mandatory traditional therapy failure, a long duration of groin pain, and the inability of these athletes to perform at a top level. The significance of the study conclusions was enhanced by a moderately large cohort of 72 athletes with meticulous (100%) data capture. The efficacy of treatment was demonstrated by pain improvements (81%) and a percentage rate of return to unrestricted sport (92%) that far exceeded any possible placebo effect and by returning athletes to unrestricted sport promptly (in less than 3 mos). Finally, the durability of response in these elite athletes was demonstrated by the rare (three

athletes only) additional treatment required to maintain unrestricted sport participation in the group as a whole. Durability was further emphasized by maintenance of unrestricted sport status in all athletes who were followed up for a minimum of 3 yrs (range, 38–73 mos), despite participation in physically stressful sports.

This study expansion of regenerative injection in elite athletes confirms efficacy in two major kicking sports (rugby and soccer). Other possible conclusions to draw from this study include the following: (1) the iliopsoas may be a secondary reactor rather than a sustaining factor in chronic groin pain; (2) the adductors may be a solo pathology in some cases; (3) radiographic study may perhaps await a treatment intervention trial; and (4) reproduction of pain with resistance and elimination of pain by injection is very useful to determine the adequacy of regenerative solution delivery to a given area and in confirming the primary nociceptive source.

Current publications are now demonstrating radiographically (via high-resolution ultrasound) the ability of simple dextrose injection to regenerate ligament and tendon.[8,26] Radiographic proof of dextrose injection's ability to "heal" tendinopathy, coupled with results of this study, may provide enough information that athletes can be persuaded to be compliant with random assignment in a future study.

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