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Proposing Return to Sport Criteria after Chronic Lateral Ankle Instability Surgery

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Abstract

Chronic instability is a complication of the lateral ankle sprain that can be treated surgically. There is currently no objectively defined criterion to authorize the resumption of sports activities to patients who have undergone this kind of surgery. The objective of this work is to define objective criteria for returning to sport after ankle ligamentoplasty as well as the deadlines corresponding to the various sports activities. Thus, a literature review was carried out on postoperative follow-up and return to play. Nine studies were analysed according to the main pre- and post-operative criteria of ankle movement amplitude, muscular force evaluated by handheld or isokinetic dynamometry, proprioception and static upright posture and time to return to sport.

If some of the results obtained in the analysed works show an improvement of these criteria in post-operative, the subjects having benefited from repair surgery of the lateral ankle instability would show a reduction of the amplitude in inversion, a defect of evertor muscles strength and postural disorders. The average time for this type of population to resume training is around the 3rd post-operative month and the resumption of competition around the 6th month.

This work underscores the importance of evaluating the post-operative musculoskeletal qualities of reconstructive surgery for chronic lateral ankle instability since problems may persist when resuming the recommended sport.

Keywords: Ankle sprain; Chronic lateral ankle instability; Ligamentoplasty; Isokinetic; Eturn to sport

Introduction

CLAI is a common complication after LAS. The likelihood of developing CLAI increases with the recurrence of LAS [1]. Indeed, LAS is a very common pathology with an incidence in France of nearly 6000 cases per day [2]. Bauer and all explain that the prevalence of CLAI after LAS is 20% to 40% [3]. Herzog and al account in 2019 for nearly 2 million ELC in the United States of America [4]. He explains that around 70% of this population who have suffered from a LAS is at risk of developing CLAI [5]. In competitive sport, whatever its level, 10% to 30% of injuries are LAS, according to Kobayashi and al [6].

It is necessary to distinguish functional instability (neuromuscular imbalance without laxity) and instability on chronic laxity (abnormal displacement of the talus compared to the bimalleolar forceps objectified by physical examination *via* a forced varus test and anterior drawer) [7]. This second description corresponds to the CLAI [8]. However, the instability of a joint generates a poor distribution of the stresses applied to it, and thus promotes the formation of osteoarthritis according to Kobayashi and al [9]. Treatment for CLAI is essential both for preventing deterioration of the joint and for resuming sport safely [10,11].

LAS relates to the lateral ankle ligament or CFL. The CFL has 3 bundles: the anterior bundle or ATFL, the middle or CFL, the posterior bundle or PTFL [12]. In the injury, one or more of the LCF bundles show partial or total distension or rupture [13]. Treatment for CLAI should therefore resolve the absence or ineffectiveness of part of the CFL [14]. The surgical indication relates to the feeling of instability of the patient but also to the laxity of the lateral compartment of the ankle as well as the number of recurrences of LAS [15]. Thus, these are the most active subjects who will be affected by these procedures and more particularly those who wish to resume a sporting activity [16].

According to Bauer and al, there are several surgical procedures allowing either the repair of the ligament, or ligamentoplasty [17]. These techniques are divided into two types of reconstruction. The so-called anatomical reconstructions, following the path of the ligaments forming the CFL and using various graft captures (tendon of the plantaris, gracilis, fascia-lata), and the non-anatomical or substitutional ones which divert the tendon of the fibularis brevis to form a lateral reinforcement [18].

Overall in their review of the literature show that patients who have undergone lateral ankle ligament surgery return to sport but at lower levels than those at which they practiced before injury [19]. The question that is raised is obviously why

because the subjects regained physiological joint stability thanks to the intervention, as shown in the study according to the procedure of Colville [20]. If the problem does not come from passive joint stability, it is that other criteria, specific to each individual, must be taken into account in order to allow safe RTS [22].

The meta-analysis published in 2016 showed that there were certain risk factors for LAS: A high BMI, a deficit in mobility in dorsiflexion, a decrease in the strength of the evertors in eccentric at low speed and an increase in rapid concentric plantar flexion force, a proprioceptive deficit and consequently, disorders of static posture [23]. These factors are also found in the CLAI according to the work of 2018. Indeed, their review states that a reduction in ankle mobility, a strength deficit and postural disorders are found on the injured limb [24]. In addition, they explain that the kinematics of walking, or running, are disturbed with an ankle placement in eversion at the time of the step attack and an increase in knee flexion (which can be restored by rehabilitation) and that these observations are found in the jump on one leg [25]. These factors are all points on which it is essential to have a restored function to allow the resumption of physical activity, whatever the level [26].

To our knowledge, there is no literature that specifically examines the objective criteria that can authorize RTS after CFL ligamentoplasty in the treatment of CLAI [27]. We propose to make an inventory of the literature and concrete criteria which can guide the therapeutic choice [28].

Material and Methods

Focusing on the criteria for returning to sport after corrective surgery from the ILCC, the keywords were determined *via* CisMef in international language [29]. These are: Ankle ligamentoplasty, lateral ankle instability surgery, return to sport and isokinetic [30]. The research equation obtained is (ankle ligamentoplasty or chrisman-snook or hemi-castaing ligamentoplasty or fibular periosteal flap or brostrom or reconstruction of lateral ankle ligament or lateral ankle instability surgery [mesh]) AND (functional outcome OR assessment OR isokinetic OR muscle strength OR posture OR balance OR gait OR walk OR jump OR run OR range of motion OR return to sport OR return to play OR athletes) [31].

Searching the PubMed scientific database on December 26, 2019 yielded 622 results. To limit the number of results, the following filters have been applied: Publication dates: 15 years, Species: Humans, clinical trial, 124 results are obtained [32]. Articles whose titles included our search terms were included as well as articles similar to the articles already selected to increase study potential [33]. Only studies written entirely in English were included for analysis [34]. Original articles, case reports or literature reviews or meta-analysis are not selected.

Articles selected for reading titles/summaries must meet certain criteria. The criteria for inclusion of the articles are studies looking at adult subjects who have undergone reconstructive or substitutive surgery of the CFL without distinction of technique. The evaluation criteria for these interventions had to concern the muscular force evaluated by isokinetic dynamometry, the amplitude available on the ankle, the quality of walking and/or running, the bipodal or monopodal comparative posture of the non-operated limb, or a qualitative study of jumps. The exclusion criteria relate to articles mentioning rheumatoid arthritis, pediatrics, CLAI without intervention, neurological pathology, ankle fracture, evaluation of various rehabilitation protocols. The articles mentioning only qualitative scales as an assessment of the success of the various interventions were excluded from the analysis. After reading the titles and summaries, 12 articles were selected for full reading.

In order to refine the selection, an evaluation of the study methodology was carried out. Those that do not follow the IMRAD structure, that have significant bias or that do not present their results, in an objective and exhaustive manner, have been ruled out. After full reading, 9 studies were included for the comparative analysis. The development of the research is summarized in **Figure 1**. In total, these are 6 operating techniques which are compared *via* 577 patients and 15 control subjects.

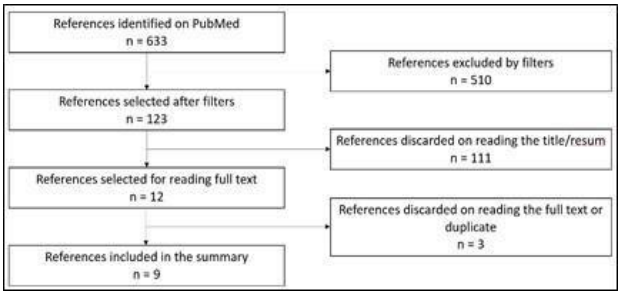

Figure 1: Flow charts which summarizes the development of literature research.

Results

All the results are presented in the **Table 1**. The results of the comparison of the studies are very dispersed because we wanted to observe the functional state of the subjects after intervention by the CLAI and this calls on many categories which are not studied in each of the selected studies.

Range of motion

The range of motion of the ankle has been studied by 4 studies on ligament sutures or ligamentoplasty. According to the two separate studies carried out at three post-operation, the subjects, amateur athletes, recover the full range of motion, however specifying whether this recovery observed is compared to the asymptomatic side or ipsilaterally but before intervention. The work of 2010, show that after ligamentoplasty, a significant deficit in ankle mobility could persist, regardless of the movement analysed. However, this deficit is on average less than 6° so the question arises of the accuracy of the measuring tool, a goniometer, without specifying what type, therefore with a standard error of 5, for an experienced operator. Only the study by Hsu and al from 2016, would show a deficit of average mobility in inversion of 59% ± 15% compared to the healthy side, on a population operated by

Brostrom-Evans technique modified at 5 years post-procedure. Indeed, the ankles operated would have an average inversion mobility of 20° ± 6° against 34° ± 5° on non-operated ankles. The other movements would not be limited in their mobility.

According to the studies analysed, only inversion mobility could be limited by the intervention of long-term ligament repair.

Muscular strength

Muscle strength has been studied by 3 studies, one using a manual dynamometer and the other two using an isokinetic dynamometer.

Concentric peak torque (Nm)	Study of Baray	Study of Cho	Control subjects of Baray
Evetors	12.7 ± 6.3	7.7 ± 3.4	14.8 ± 8.1
Invertors	11.7 ± 4.6	11.4 ± 4.4	12.9 ± 5.8

Table 1: Comparison of the muscular forces obtained by isokinetic at 120°/s.

From the **Table 1**, it would seem that there is an important difference between the work of 2016 and 2018.

Indeed, in this last study, the average force of evertors measured at 120°/s is 7.7 ± 3.4 against 12.7 ± 6.3 for the patients of the irst study and 14.8 ± 8.1 for its control subjects. It would seem that the tendency is for a de icit in the muscular strength of the evertors at 6 months post-operation, measured at high speed equivalent to the concept of muscular endurance. Cho and al measure this force at 2 years post-operative and obtain 8.9 ± 3.5, a decrease still present with a bilateral de icit ratio of 7.3% (not significant).

The study by shows a signi icant decrease in the strength of the concentric invertors at 30°/s compared to a control population at 6 months post-operation, a ter adjusting for weight, age and dominant side of the test subjects. The other studied values of muscle strength seem to be comparable to the norm.

The study of goes in favor of improving the peak strength of the evertors regardless of the speed evaluated between the pre-operative and post-operative values at 2 years, therefore in favor of a partial recovery of the muscular strength of the evertors a ter ligament repair. The de icit in the bilateral peak force ratio for evertors at an angular speed of 60°/s was signi icantly improved, going from an average of 38.6% preoperatively to 17.4% at 2 years postoperatively.

If it seems that there is an improvement in the muscular strength of the evertors a ter intervention of correction of the CLAI, there could nevertheless persist a de icit of strength and endurance of the evertors at 6 months post-operative.

The study conducted in 2016 measures muscle strength by a manual dynamometer at 5 years post-operative. The authors find on average a deficit of strength of the evertors compared to the non-operated side, with 141 N ± 15 N against 155 N ± 20 N, that is to say a significant reduction in the muscular force of 9%. The other muscle groups tested (invertors, lifters and propellants) showed no strength deficit.

Studies analysing muscle strength using an isokinetic dynamometer only agree on a fast speed parameter, at 120°/s, the results of which at 6 months are listed in **Table 1**. Slow speeds are not the same and only one study uses eccentric mode.

Deadline for return to sport

The delay in returning to sporting activities is the phenomenon most studied by the selected studies since six studies mention it. However, the target audiences for the studies seem very distinct in their levels of sporting practice but also in the definition of RTS.

The work of analysing the performance of an amateur sports population after treatment of CLAI by sutures using various techniques, explores the delay in returning to jogging and then to explosive running. The subjects having benefited from Anchor suture take an average of 10.4 weeks to resume jogging against 9.8 for subjects having benefited from bridge suturing and 8.4 for subjects operated by modified Brostrom techniques. For the resumption of the explosive running, the subjects take 14.5, 13.8 and 12.5 weeks respectively.

The study published by studies the delays of RTS in a population of athletes registered on the Korean lists of high level or junior athletes, operated by suture according to the modified Brostrom technique. Personal training would be resumed in 1.9 ± 1.2 months, approximately 10 weeks, which would correspond to the resumption of jogging in a population of amateur athletes. The team training would be resumed at 2.9 ± 1.0 months and the return to competition (return to play) would be resumed at 3.9 ± 1.4 months. It is important to emphasize that the population studied here is very young, 19.3 years on average, and high level sports, which can shorten the RTS times. These conclusions could not apply to an amateur or older athlete population.

On a non-professional sports population, but this time, operated by ligamentoplasty according to the hemi-castaing technique, expose a delay of RTS, for all the subjects analysed,

Intervention	Suture anchor	Bridge suture	Brostrom	Brostrom modified	Hemi-castaing
Study	Cho	Cho	Cho	Lee	Sperati
Sport level	Casual	Casual	Casual	High level athletes	Non-professional athletes
Running	10.4	9.8	8.4	8.36 ± 5.3	-
Speed running	14.5	13.8	12.5	-	-
Team training	-	-	-	12.8 ± 4.4	[11.4 -14.3]
Competition	-	-	-	17.2 ± 6.2	-

Table 2: RTS expressed in weeks according to the surgery.

between 80 and 100 days after surgery, between 11.4 and 14.3 weeks. Two studies study not the delay of RTS but its existence alone. Thus, in the subjects observed by Lopes and al in 2018, recreational athletes could return to the same level of sport (90% in the repair group and 80% in the ligamentoplasty group). Almost three-quarters of competitive athletes returned to the same level of sport after repair (73%) compared to less than half after reconstruction (48%).

The 2010 study by Kramer and al on subjects operated on for ligamentoplasty using the Chrisman-Snook technique, 92% of the cohort would finally return to sport, 80% of which at 6 months postoperatively. Football players would be in more difficulty and resume later than other sports. In the end and whatever the initial level of play, 25% of athletes would not resume at the same level.

According to the studies analysed, all athletes (all levels combined) would not resume sport or not at the same level. The average time for this type of population to resume training is around the 3rd post-operative month and the resumption of competition around the 6th month.

Other parameters

Studies regularly analyse functional scales that can be filled by the subject himself and thus reveal the subjectivity of their use. The AOFAS is a score used in three of the selected studies: Out of 100 points, the higher the score, the more functional the ankle.

In the long-term post-operative (between 6 months and a year), the work of show respective scores 89.1 ± 16.2, 90.5 ± 7.2, 89.8 ± 8.5 and 89.2 ± 13.3. These results seem to show that in the long term, surgery can restore a functional and painless ankle.

A study, that of studies proprioception and posture after ligamentoplasty by hemi-castaing at 6 months post-operation. Proprioception, analysed by the joint position sense test, seems to be equivalent to that of the control population. However, the bipodal or monopodal standing posture, on the operated or asymptomatic limb, seems deficient in the operated subjects with a significant increase in the stabilometric parameters.

Discussion

Deadline for return to sport

In 2013, published long-term results on athletes following a Brostrm procedure and found that 58% were able to return to their level of sport before the injury, 16% were still in competition but at a lower level and 26% had stopped practicing sport but were still physically active. These data are correlated with the studies selected for the analysis: not all athletes will return to sport or at least not at the same level. Therefore, it is essential to validate objective criteria which can indicate the safety of resumption of sport for each patient.

Range of motion

The results of this study, concerning the recovery of joint range, are in favour of total recovery. This information must be weighted according to the populations studied by the studies and by the various immobilization treatments after surgery: In the two studies by athletes are studied, while the level of sports practice is not a criterion for inclusion in the studies of Kramer and al or Hsu and al. For the first two studies, the patients are immobilized by plaster for three weeks, 4 for the study and 6 for the study for Hsu, which may be explanations for the mobility deficit found in the latter. However, in the studies cited, mobility on the contralateral side is taken as a reference value. Knowing that there is a prevalence of sprain and therefore, a mobility which tends towards important values of mobility, without speaking of laxity, we can wonder about the interest of this reference.

Total recovery of the functional range of motion (depending on the type of sports practice) can be considered as a criterion for validating a return to sport.

Aofas functional score

The studies selected for the analysis seem to agree on a high AOFAS score in post-surgery, around 90%. These results are in agreement with the literature: Indeed, Yong and al in 2015 for a population having benefited from ligament repair present an average score of 91.5 AOFAS in the long term, or the team of Zhang who in 2017 found an average score of 90.4 at the last

follow-up visit (at more than 6 months) after a semi-tendon ligamentoplasty. The AOFAS functional score, very well represented in the literature with an interclass correlation of 0.81 for ankle pathologies according to in 2014, is a good indicator of ankle functional recovery, however, it To our knowledge, there is no literature concerning its interest in the resumption of physical or sporting activity.

Posture

The work of on individuals with CLAI, show that compared to the asymptomatological side, the statesthesia deficit ratio, evaluated by the JPS, was around 40.7% and 47.2% at 10 and 20 degrees of inversion angle, respectively. On this same population, the modified Romberg test (monopodal evaluation) would show a deficit of 49.4% on the lower limb presenting CLAI compared to the unaffected limb. Ankles with CLAI would therefore suffer from a proprioceptive and postural deficit.

These data are also found by who objectify dynamic postural deficits, evaluated by the Star-Excursion Balance Test, according to various methods. These authors associate this postural deficit with a decrease in the strength of the stabilizers of the pelvis homolateral to the injury. In a prospective study in 2017 found that a reduced isometric force of the pelvic stabilizers (hip abductors=gluteal deltoid) would predispose competitive male football players to contactless LAS.

The study by concerning a population operated by ligamentoplasty using the hemi-casting technique, would show total recovery on the proprioceptive and postural level, compared to the healthy member. These data are in correlation with the analysed study by which this time compares the operated population to a healthy population, validating proprioceptive and postural recovery.

Thus, if proprioception and posture would be restored after lateral ankle ligamentoplasty, this deficit, which is treatable by rehabilitation according to in their work of 2017 could be a risk factor for the occurrence of an episode acute LAS, as is the isometric strength deficit of the pelvic stabilizers. These two criteria are therefore to be assessed before authorizing a resumption of training or competition in the athlete.

Isocine ic muscle strength

At the present time, to our knowledge, there is no consensus of recommendation concerning the isokinetic evaluation of the strength of the muscle groups of the leg segment. If the studies analysed agree that it is necessary to evaluate the groups of inverters and evertors at slow and fast speeds, they do not agree on these speeds nor on the mode of contraction to be evaluated (concentric only or eccentric of the low speed evertors also).

The studies analysed agree that there may persist a deficit in strength and endurance of the evertors at 6 months post-operative after ILCC surgery. In a 2014 study carried out on a population having benefited from a hemi-castaing ligamentoplasty found, that at 18 months post-surgery on average, that the subjects presented a muscle strength significantly reduced on the invertors compared to the healthy side in concentric at 30°/s and 120°/s and in eccentric at 30°/s. The results for the evertors are in favor of a reduction in strength but in a non-significant way, thus contradicting the results of this study. However, the mere comparison with the healthy side may not be sufficient in which case it would also be a question of comparing to a control population, thus allowing better objectivity of the results.

Regarding the angular velocities of muscular evaluation, the systematic review with meta-analysis by conclude that, after CLAI, the evaluation of strength is an important element of the criteria for return to play. Based on this finding, the authors recommend performing clinical tests using a speed greater than 30°/s and less than 240°/s.

At high speed, all the studies analysed chose 120°/s. In pure force at slow speed, the selected studies sometimes use 30°/s, sometimes 60°/s in 2004 conclude their study by saying that isokinetic inversion and ankle eversion force tests at angular velocities of 60 and 180°/s in neutral position of the foot for adults in good condition are very reliable with inter-class correlations of [0.92-0.96] in inversion and [0.87-0.94] in eversion. The work of In 2004 who explain that isokinetic inversion/eversion tests have been shown to be reliable at 30°/s and 120°/s in a population that has recently undergone LAS. Isokinetic inversion and eversion tests can be used to assess the resistance properties of a population with recurrent lateral ankle sprain and to detect specific deficits in muscle performance.

In a study on healthy subjects of 2016, explain that the values of the peak of force, evaluated by isokinetic, vary significantly between sex (with values significantly greater for men than women in the movements of plantar and dorsal flexion) and with the subject's weight. Thus, the use of the peak of force alone is not recommended but rather the value of the peak of force, normalized by the weight of the subject.

Already pointed out in 2003 the need for the eccentric evaluation of the evertors, especially at the end of the inversion amplitude, because it is the mode of muscular contraction linked to the sprain mechanism. The ratio of eccentric evertors to concentric invertors was much lower in subjects with instability. This ratio is calculated on the basis of a movement of 120°/s in concentric and eccentric. In agreement, as early as 1994, suggested that the power ratios be used to evaluate the evertors/invertors between the dominant and non-dominant ankle and that these ratios should be around 65% and 75%, respectively. This work finds support by those of in 2011, who find, on populations suffering from LAS or CLAI, a reduced force on the eversors at 30°/s, as our analysis concludes, but also a 30°/s concentric evertors/invertors ratio reduced compared to a control group of the same sporting level.

Furthermore, explain in 2018 that there is no strong correlation between muscle strength deficit and sensory deficit in an CLAI population. We conclude that given the weak association between ankle strength and postural stability, an appropriate post-operative follow-up examination should include both muscular and postural stability.Thus, after ILCC surgery, invertors and evertors muscle strength tests evaluated by isokinetic are recommended tovalidate the return to sport.

It seems that the normalized force peak at weight and the evertors/invertors ratio are interesting measures to analyse even if there is no consensus as to their respective normative values. It also appears that a low speed 30°/s and high speed 120°/s concentric test as well as an eccentric test of the eversors are also recommended. The reference values of the strength of the muscles of the leg segment are to be defined. Merely comparing the force values obtained with those on the healthy side would not be sufficient, hence the need to define, depending on the weight and level of sporting practice, reference force values.

Proposed criteria of RTS

Unlike the much studied ligamentisation of the grafted tendon to reconstruct the ACL, we can only deplore the lack of work concerning the various ankle ligamentoplasty surgeries. Explained, as early as 1993, that the process of ligamentisation of the grafted tendon to become ACL took: (0-2 months) cell colonization, (2-12 months) collagenous remodelling with significant fibroblastic activity and neovascularization and areas of degeneration, (1-3 years) decrease in cells and vascularity, maturation of collagen fibers and (+3 years) histological aspect of the ligament. The work of showed that with a periosteal tendon ligament, there was realignment of collagen fibers in 8 to 12 weeks then complete ligamentisation of the tendon around the 6th month. This stage can be considered as a pivot for the resumption of physical activities and can thus be considered as a reasonable period to complete the test battery validating the return to sport.

If each of the criteria must be tested independently to be validated, we are able to advise the following battery in order to confirm the resumption of sport after CLAI repair surgery: Clinical examination attesting to a functional articular amplitude of the ankle and hindfoot, postural analysis of the bipodal then monopodal standing position showing no deficit, gait analysis without lameness. Concerning the analysis of isokinetic muscle strength, it is necessary that the lower limbs show a difference of less than 10% of force between the operated side and the healthy side in concentric mode at speeds of 30°/s and 120°/s, an evertors/invertors ratio at 30°/s and an eccentric mean torque at 30°/s for the evertors whose reference values are still to be defined. Moreover, it would be relevant to compare the values obtained with standards, defined according to the weight and level of sports practice of the subject. The addition of a functional test will also be important in order to determine the neuromotor capacities of the subjects before returning to sport, we therefore advise to analyse the parameters of a hop test, the validity of which has already been demonstrated in other circumstances.

Methodological considera ions

This work is not intended to be exhaustive and has some limitations. No systematic analysis of the level of evidence of the selected studies has been carried out, making the bibliography non-homogeneous in terms of quality. Furthermore, only nine studies could be included in the analysis making the conclusions drawn here to be taken in hindsight. The studies analysed present for some small cohorts by group (<20 patients) thus reducing the power of the results; most do not have a control group. The subjects from the groups to be compared are not necessarily stratified according to their physical characteristics (height, weight, age), making the comparisons questionable. In addition, only one database was queried, reducing the power of the results obtained.

Conclusion

Restorative surgery for CLAI is very diverse and has many techniques, the superiority of which is not intended to be assessed. After this surgery, some deficits seem to persist. Before allowing beneficiaries to resume sport, objective tests may be recommended to avoid iterative injuries or treatment failures. These examinations, whose benchmarks are to be defined, would guide the therapeutic choice and would improve the support for patients who wish to resume their sport activities.

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