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Original article

Efficacy of corticosteroid injection in rock climber's tenosynovitis

Efficacité des injections de corticostéroïdes en cas de ténosynovite chez les grimpeurs

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ABSTRACT

While many finger conditions in climbers have been studied extensively, no data exist on the treatment of rock climber's finger flexor tenosynovitis. The purpose of this study was to evaluate the outcomes after corticosteroid injection. The study included rock climbing athletes suffering from chronic (longer than 6 weeks) finger flexor tenosynovitis who were seen at our clinic in 2017. All 42 patients received two corticosteroid injections within a 7–10 day period. Thirty-one climbers (73.8%) were pain free after the second injection and a mean of 20.9 ± 23.1 days. The climbers reported an 84.2% decrease in pain level and no complications. The positive outcome after corticosteroid injection therapy and the absence of complications justifies this invasive approach in rock climbing athletes.

RÉSUMÉ

Il existe déjà des études très poussées sur l'état des doigts chez des grimpeurs de haut niveau, mais il n'en existe aucune sur le traitement d'une ténosynovite des fléchisseurs du doigt. Notre étude avait pour but d'évaluer les résultats d'injections de corticostéroïdes chez le patient. L'étude a inclus les athlètes grimpeurs souffrant de ténosynovite chronique des fléchisseurs du doigt (plus de 6 semaines) dans notre clinique en 2017. Tous les patients (42) ont reçu 2 injections de corticostéroïdes en l'espace de 7 à 10 jours. Trente et un d'entre eux (73,8 %) n'avaient plus de douleurs après la seconde injection, à un délai compris entre 20,9 et 23,1 jours. Les symptômes ont été réduits de 84,2 %, sans complications. Le résultat positif obtenu après injection de corticostéroïdes et l'absence de complications justifient cette nouvelle approche chez des athlètes grimpeurs.

1. Introduction

With an estimated more than 10 million climbers in the USA [1], rock climbing is a very popular sport and will be included in the Olympic program in Tokyo 2020 [2]. The perception shift from climbing being an extreme, niche sport to a mainstream activity combined with the increasing professionalism within the sport has resulted in more intense training regimens and an increased probability of overuse injuries [2–6]. Overall, most acute climbing injuries are the consequence of a fall and result in ankle sprains and strains [6,7]. The most sport-specific climbing injuries are found in the hand and fingers [6–8]. The acute injuries most frequently seen in our clinic are to the flexor tendon pulleys. The most acute overuse injury is finger flexor tenosynovitis [9]. The latter condition is commonly referred to as tendonitis by laypersons and climbers but it is in fact an inflammation of the tendon sheath [8,10]. The correct term is tenosynovitis, which is the most

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important differential diagnosis to pulley injuries and the most frequent overuse syndrome in climbers' fingers [8,11]. An inflammatory response occurs after repetitive stress and its onset can either be acute–after one exceptionally challenging training/climbing day–or slowly develop over several days [8]. The climber suffers from pain, occasionally accompanied by minor swelling along the volar surface of the digit, around the same area as a pulley injury. The pain can extend into the palm or the forearm. Diagnosis can be made through ultrasound, which detects a "halo" phenomenon around the tendon [8,10,12]. This increased accumulation of fluid around the tendon is most clearly visible on a transverse image [13]. As climbers tend to have more fluid in their flexor tendon sheets after high stress period, no clear information can be given about the normal range [8]. It is best to compare the ultrasound findings on the injured finger to the same finger on the contralateral side [8]. Treatment consists of anti-inflammatory medication, splint immobilization for several days, externals, brush massages, ice therapy and, in persisting cases, local cortisone injections [6,8]. These injections are not always avoidable, as chronic tenosynovitis can be stubborn.

While acute finger flexor tendon pulley injuries have received a lot of attention in climbing specific research [6,11], little research on the treatment of flexor tenosynovitis has been presented [8]. The medical literature only provides studies on tenosynovitis in combination with trigger finger or extensor tenosynovitis (DeQuervain) [14–16]. Unfortunately, there are no histopathological studies on rock climber's tenosynovitis, thus we cannot conclude this condition is similar to the one in trigger finger. However, the clinical and ultrasound description defines a common homogeneous entity, thus we propose to use the term "rock climber's tenosynovitis" to differentiate it from other tenosynovitis conditions. Based on the assessment of prior patients [8,9]–who were not included in this study–we developed a stage-related treatment regimen based on the severity and time frame of clinical and imaging findings.

Within this stage-related treatment regimen (Table 1), stage 1 cases receive conservative therapy of self-massage with an acupressure ring, or brush massages (with a toothbrush) to stimulate blood flow [8]. In addition, local overnight ointment dressings with Ichtholan® 20% (Ammonium bituminosulfonate, Ichtyol®, Hamburg, Germany) are applied for 10 days. The climbers are advised either to rest or to implement H-taping during climbing, depending on the extent of the complaints or professional ability (e.g. rest is not possible during World Cup season). H-taping biomechanically deflects the angulation of the tendon and thus decreases friction at the distal rim of the involved pulley [17]. All stage 2 patients (either having complaints for more than 6 weeks or after failed conservative treatment for 4 weeks) receive corticosteroid injections. The purpose of this study was to evaluate the outcomes after corticosteroid injection therapy.

2. Patients and methods

In 2017, we prospectively identified patients in our sports medicine outpatient clinic who presented with rock climber's tenosynovitis and studied the efficacy of corticosteroid injection in patients with pain of more than 6 weeks' duration or after failed conservative therapy of more than 4 weeks: stage 2 in our classification (Table 1). This study was approved by the ethics board of the Friedrich Alexander University of Erlangen–Nuremberg.

2.1. Patient selection

Diagnosis was made through patient history, clinical findings and ultrasound evaluation. The following criteria were considered as evidence to support the diagnosis of rock climber's tenosynovitis:

- volar-sided finger pain during or after climbing [8,18];
- point tenderness on the volar aspect of the finger [8,19];
- halo phenomenon in the ultrasound evaluation [8,12,13,20,21]: the ultrasound evaluation was performed with an 18 MHz linear transducer (Logic Q, General Electric Healthcare, Chicago, USA) in longitudinal and transverse planes. The diagnosis was confirmed by increased fluid (halo phenomenon) (Fig. 1) distal to the respective pulley within the tendon sheath at the level of point tenderness, which was more than 2 mm in the transverse plane (if the contralateral finger did not have similar findings) [8,12,13]. If there was a similar fluid accumulation in the contralateral (symptom-free finger) finger, the difference in size of the halo-phenomenon between the injured and healthy fingers was measured and a difference of more than 2 mm (injured versus healthy) was considered as proof for the diagnosis;
- absence of a pulley rupture or other injury [8,12,13,20–22]: a pulley rupture or another injury was excluded by the standard ultrasound diagnostic criteria of increased tendon-to-bone distance during forced flexion [10,12,20,22].

2.2. Injection therapy

Injection therapy was performed using a crystalloid cortisone (dexamethasone) in a prefabricated mixture with lidocaine (Supertendin®, Carinopharm, Elze, Germany). A volume of 0.1–0.2 ml was administered per injection. The location of the injection was the largest point of the halo ring as seen in the ultrasound. The injection was performed in two steps. In the first step, after skin disinfection, the needle was inserted through the skin at a 60° angle pointing toward the fingertip until it reached the flexor tendons. The patient was then directed to flex the finger, causing

Table 1
Treatment regimen for tenosynovitis of the finger flexor tendons in climbers.

Stage	Time frame since onset of pain	Treatment	Climbing rest
1	< 6 weeks	Conservative, icing, local therapy with acupressure ring	0–14 days, then stepwise climbing load increase with H-taping [18]
2	> 6 weeks (or after failed conservative therapy > 4 weeks)	Local injection of "Supertendin®" (corticosteroid) re-injection after 7–10 days	No climbing or hand-related sports in between the injections and for least for 10 days after the second injection, then stepwise climbing load increase with H-taping [18]
3	Persistent pain > 6 weeks after second injection	Medicinal leech therapy	14-day rest, then stepwise climbing load increase with H-taping [18]
4	Persistent pain > 6 weeks after failed leech therapy	Surgical tenosynovectomy	6-week rest, then stepwise climbing load increase with H-taping [18]

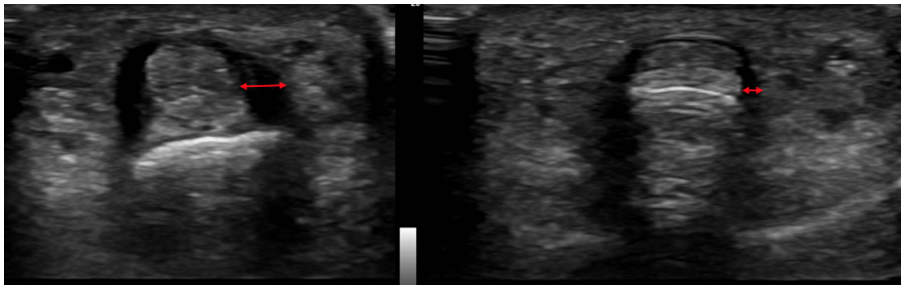

Fig. 1. Halo phenomenon in rock climber's tenosynovitis (left) compared to the contralateral healthy finger (right).

the needle to move with the flexor tendon. The needle was retracted until the tendon could move freely and only the tip of the needle remained in contact with the tendon, at which point 0.1 ml was injected (Fig. 2). In the second step, the needle was inserted further through the flexor tendons until it reached the bone. This guarantees that the needle tip's open lumen is in the space between the lower surface of the flexor tendons and the bone, at which point the second injection was administered (Fig. 3).

2.3. Outcome measures

The duration of follow-up was 6 months after the last treatment and was performed either by clinical examination or telephone contact with the patient. The overall outcome was analyzed using the Buck–Gramcko score [23] (Table 2) and the previously published functional and climbing-specific finger injury outcome scores [24] (Tables 3–4). The pre- and post-treatment climbing level was calculated according to the UIAA MedCom scale [25]. Pain in daily life and during and after sport was evaluated using the VAS (visual analog scale 1–10).

3. Results

Forty-two patients received the two corticosteroid injection regimen. Seven patients were female and 35 were male, with an average age of 33 ± 9.5 years. Eight patients reported a prior condition of the affected finger (4 recurrent tenosynovitis, 2 capsulitis, 1 pulley rupture, 1 osteoarthritis). Nineteen patients had not yet received any specific therapy and 23 had undergone prior therapy with NSAID, ointment dressings, finger massage ring, rest or taping.

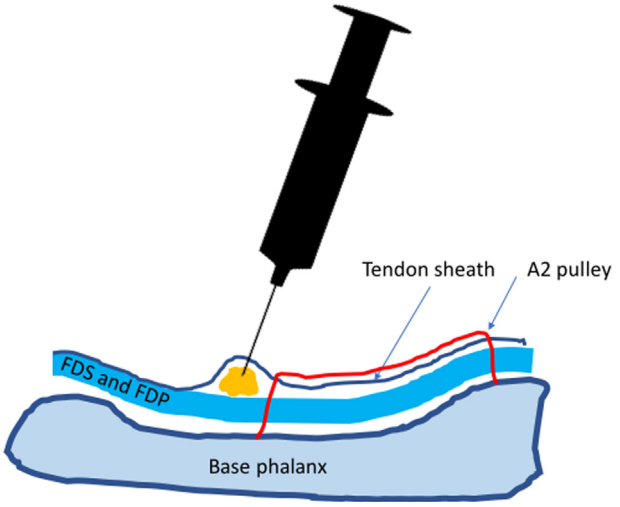

Fig. 2. Injection position into the flexor tendon sheath compartment.

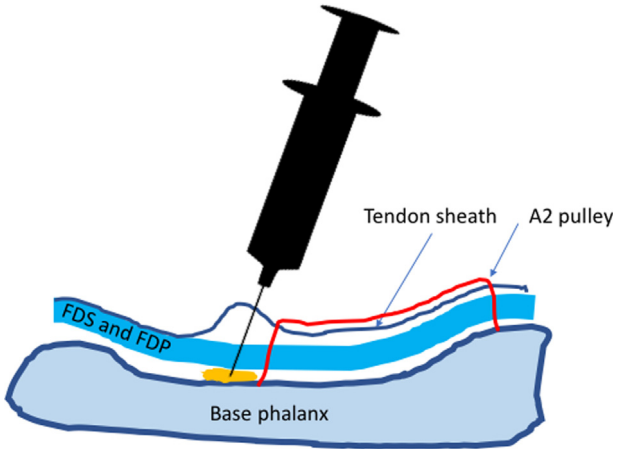

Fig. 3. Injection site underneath the flexor tendons.
Table titles

The symptoms of point tenderness to pressure, pain during activity and, in 13 patients, occasional pain during rest had been present for 14.7 ± 9.4 weeks. All patients had pain during or after climbing and 17 also had pain in normal daily life (VAS 1–5). The pain level during climbing was 4.8 ± 1.3. Table 5 shows the 42 patients who received corticosteroid injections. The mean climbing level was 9.0 ± 1.3 UIAA before the injury and 8.6 ± 1.2 UIAA after treatment. It ranged from UIAA 7 to world leading expert level UIAA 12. After the injury and treatment, the climbing level decreased in one athlete, increased in one and remained unchanged in 40 climbers. Thirty patients were recreational climbers, nine were ambitious/semiprofessionals and three were professional climbers. Thirty-one of the climbers (73.8%)

Table 2
Buck Gramcko score [19].

Measurement of digits II-V	Points
Finger-to-palm distance/complete flexion	
0–2.5 cm/≥200?	6
2.5–4 cm/≥180?	4
4–6 cm/≥150?	2
> 6 cm/<150?	0
Extension deficit	
0?–30?	3
31?–50?	2
51?–70?	1
>70?	0
Range of motion	
≥160?	6
≥140?	4
≥120?	2
<120?	0

Grading: 14 or 15 points: excellent; 11–13 points: good; 7–10 points: fair; 0–6 points: poor.

Table 3
Functional outcome score after finger injury in climbers [20].

Functional outcome after treatment of closed pulley injuries
Excellent: full range of motion, no objective strength deficit, normal motion pattern
Good: up to 10? extension- or flexion deficit of the PIP joint, minor strength deficit, normal motion pattern
Satisfactory: up to 20? extension- or flexion deficit of the PIP joint, clinical strength deficit, minor alteration of motion pattern
Fair: more than 20? extension- or flexion deficit of the PIP joint, major strength deficit, major alteration of motion pattern

PIP: proximal interphalangeal joint.

were pain free after the second injection at a mean time of 20.9 ± 23.1 days. The remaining 11 were not completely pain free. No local complications (infection, skin necrosis, fat tissue necrosis, secondary pulley or tendon rupture) occurred. The patients resumed climbing 22.6 ± 14.2 days after the first injection and climbed with full load after 32.9 ± 16.8 days. After the injection, 39 were pain free during normal daily activities and the remaining three had persistent pain (VAS 1–2). During climbing, 24 climbers (57%) were pain free and 18 (43%) suffered from occasional pain (VAS 1–4, mean 2.6). The mean pain level while climbing after the corticosteroid injection was 1.1 ± 1.7. Of the 18 patients with persistent pain, 9 entered Stage 3 (see Table 1) and received further treatment; the other 9 accepted the residual low-level pain and continued climbing with full load. The Buck-Gramcko (Table 2) score and the functional result score (Table 3) revealed excellent outcomes in all 42 cases. The initial Buck-Gramcko score was excellent in 38, good in 3 and fair in 1 patient. The sport-specific outcome score of all 42 patients (Table 4) was excellent in 26 (62%), good in 9 (21%) and satisfactory in 7 (17%) patients.

4. Discussion

Tenosynovitis in general can be either infectious or non-infectious. Bacterial, infectious tenosynovitis in rock climbers is rare and usually caused by skin lacerations or cuts [8]. The etiology of the typical climbing-related non-infectious tenosynovitis (rock climber's tenosynovitis) may be due to the high stress applied to the fingers in climbing, mostly while performing the so-called "crimp grip" [8]. In the crimp grip, the flexor tendons are curved at the distal end of the A2 finger flexor tendon pulley, as well as the proximal end of the A4 pulley [26,27]. This leads to increased tendon flexion and thus increased friction on the rim of the pulley [17,27]. Repeating this position can lead to a chronic inflammatory reaction of the tendon sheath [8]. In general, the terminus

Table 4
Sport-specific outcome score after finger injury in climbers [20].

Excellent: full load capacity of the previously injured finger after 12 months (with or without tape), no subjective strength deficit of the previously injured finger, recovery of full climbing ability/pre-injury climbing level, no pain
Good: full load capacity of the previously injured finger after 12 months (with tape), subjective minor strength deficit of the previously injured finger, recovery of full climbing ability/pre-injury climbing level, minor pain
Satisfactory: minor restricted load capacity of the previously injured finger after 12 months (with tape), subjective strength deficit of the previously injured finger, recovery of full climbing ability/pre-injury UIAA climbing level minus one UIAA grade, minor pain
Fair: major restricted load capacity of the previously injured finger after 12 months (with tape), strength deficit and restricted ability to use the previously injured finger while climbing, major decrease in climbing ability and grade, frequent pain
Poor: climbing is no longer possible

Table 5
Patients, symptoms and outcomes.

n = 42 (7 females, 35 males)	Age	Time since onset of pain in weeks	Pain on VAS during climbing Pre-injection	Pain during daily activities	Pain on VAS during daily activities	Climbing level before injury	Climbing level after treatment	Pain reduction after 1st injection[a]	Pain reduction after 2nd injection[a]	Pain during daily activities after 2nd injection	Pain on VAS during daily activities after 2nd injection	Pain on VAS during climbing after 2nd injection
Mean	33	14.7	4.8	17 yes	0.95	9.0	8.6	60.2%	84.2%	3 yes	0.14	1.1
SD	9.5	9.4	1.3		1.3	1.3	1.2	21.3	25		0.55	1.7

[a] The climbers were asked how much the pain had decreased if the initial pain level was graded at 100%, e.g. a decrease of 60% means they still had 40% of the initial 100% subjective pain level.

"tendinopathy" is recommended (instead of tendinitis or tendinosis) as it is the best generic descriptive term for the clinical condition which arises in and around tendons from overuse [28]. As the condition in climbers is more of an inflammatory reaction with increased fluid and blood flow within the tendon sheath, the term "tenosynovitis" is most accurate in describing the climber's condition. Even though no histopathological study has been performed, ultrasound examination, including duplex ultrasound, reveals this inflammatory reaction [12,29,30]. While there are multiple extrinsic and intrinsic factors at the origin of tenosynovitis, excessive loading of tendons during vigorous training, as performed in rock climbing, is regarded as the main pathological stimulus for degeneration [31]. Tendons respond to repetitive overload beyond the physiological threshold either with inflammation of the sheath or degeneration of the body, or both [28]. Tendon damage may even occur from stress within the physiological limits, as frequent cumulative microtrauma may not allow enough time for the tendons to heal [28], a scenario that is highly likely in ambitious climbers. No other sport places such an immense load onto the fingers, especially in the crimp grip [26,27].

Treatment of rock climber's tenosynovitis of the finger flexor tendons is multifaceted. While non-invasive procedures such as icing, externals and NSAIDs are applicable in the acute state, injection therapy is frequently necessary in chronic conditions [8,14]. Nevertheless, the risk of a false injection and tendon necrosis or rupture exists [32]. Alternatively, radial shockwave therapy has been shown to be somewhat effect in the treatment of chronic, non-inflammatory tendinosis to enhance neovascularization [28]. Various substances such as corticosteroids (triamcinolone, dexamethasone), hyaluronic acid, platelet rich plasma or NSAIDs are used in injection therapy [14–16,33,34]. Additionally, several taping methods were developed and analyzed biomechanically to deflect the course of the flexor tendons and thus decrease friction to the tendon sheath [17,35,36]. Unfortunately, all the studies analyzing the outcomes of these injections in tenosynovitis cases are focused on the treatment of trigger finger tendinopathy [14–16,33,34], with a success rate of 60–92% [34,37]. Salim et al. reported these injections have the highest success rate in cases of trigger finger [34]. Nevertheless, no study reports the specific outcomes for a tenosynovitis condition like the one encountered in rock climbers. Although these injections are reported to be beneficial [8], they are also controversial, as a false intratendinous injection instead of a peritendinous injection (Figs. 2, 3) may lead to tendon rupture [6,32]. Thus, correct injection technique is essential. Other complications of steroid injections in athletes such as fat atrophy or fascia ruptures are also well known [38]. In rock climbers, we also saw two cases of a secondary pulley rupture after steroid injection. However, both athletes did not comply with the recommended rest period after the injection.

Overall, we treated 50 patients with rock climber's tenosynovitis of the finger flexor tendons in the 2017. Seven of these received primary conservative therapy (Stage 1), 42 received local steroid injections (Stage 2), and one patient, contrary to our therapy regimen, received initial therapy with a medicinal leech, as she refused an injection. Four out of the seven Stage 1 patients healed within 8 weeks and regained their initial climbing level (Buck–Gramcko score: all 15, functional outcome score: all "excellent", sport-specific outcome score: all "excellent"). The remaining three Stage 1 patients did not heal and later ($>$ 4 weeks of failed conservative treatment) underwent steroid injections. The results of the 42 patients who underwent steroid injections will be discussed further below. The patients who did not respond to the steroid injections during this study received medicinal leech (*hirudo medicinalis*) therapy. A medicinal leech was applied and left at the tenosynovitis site after needle puncture until it let go. Fourteen days of climbing rest were prescribed afterwards. Leeches act by withdrawing blood and injecting active substances through their saliva into the host tissue [39]. During this process, more than 100 substances are injected [39–41]. Active substances identified within leech saliva today include hirudin, factor Xa-inhibitor, and hyaluronidase [39]. These substances have anti-coagulant, thrombolytic, anti-inflammatory and pain relieving effects [39–41]. With these known effects as well as the positive effect on symptomatic osteoarthritis at the first carpometacarpal joint, we started using medicinal leeches as an alternative before surgery [42]. After preliminary good results in our patients with tenosynovitis and capsulitis and literature data [39–41], we added this into our therapeutic regimen (Stage 3).

Nine of the 42 injection patients received further secondary treatment. In one case, a third steroid injection was administered, and the finger healed completely. In the eight patients who underwent medicinal leech therapy, five were pain free during normal life and the remaining three reported minor pain during normal daily activities. All could restart climbing, two completely pain-free and six with minor pain with a mean VAS of 1.7. The Buck–Gramcko score and functional score were "excellent" in all cases; the sport-specific score was "excellent" in two and "good" in six patients. No complications of the leech therapy occurred.

As the current literature does not give any data of the outcome of isolated tenosynovitis treatment (without trigger finger), it is hard to compare our results. Although Blood et al. [37] report a success rate of 60–92%, they discuss patients with trigger finger and diabetes. This is only partially comparable with our data from healthy athletes in whom the sport-specific outcome was the most important, which means the pain was analyzed during stress patterns which "normal" people do not apply to their fingers. Four out of the seven conservative patients healed within 8 weeks; the others entered the injection group. We think that a conservative-first approach is certainly valuable, in agreement Jones et al. [6]. Within the injection group, we found a 84.2% decrease in symptoms after the second injection. During climbing, 24 patients (57%) were pain free and 18 (43%) had occasional pain. Only nine patients needed another adjunct therapy. All could climb again, and only one did not regain their pre-injury climbing level. There were no complications following injections. We think these outcomes justify injection therapy in the cases where initial conservative management fails. The injection must be done carefully, avoiding intra-tendinous injections at all costs. For treatment-resistant patients, medicinal leech therapy proved to be a valuable alternative with no complications. The sport-specific score was "excellent" in two and "good" in six patients after leech therapy. This alternative could be placed within the therapeutic regimen prior to injection therapy.

Our study has several shortcomings; the outcome measures did not include a quantitative imaging-based assessment and a controlled clinical trial of corticosteroid injection versus a placebo group was not carried out. Further studies are needed to examine various randomized treatment approaches against each other. Other conservative treatment options such as radial shockwave therapy [28] also need to be evaluated.

5. Conclusion

This study describes the initial outcomes of corticosteroid injection of finger flexor tendon tenosynovitis in climbers. It also demonstrates steroid injection therapy is an effective treatment with no complications in patients with a more chronic condition. The correct injection technique is crucial to avoid damaging the tendons. The application of a medicinal leech led to good results after injection therapy had failed to completely heal the patients' condition. Acute patients, who have had pain for less than 6 weeks, are still treated conservatively.

Disclosure of interest

The authors declare that they have no competing interest.

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