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SCIENTIFIC ARTICLE

Ultrasound-guided versus palpation-guided corticosteroid injections for tendinosis of the long head of the biceps: A randomized comparative study

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Abstract

Purpose To compare accuracy, patient discomfort, and clinical outcome of ultrasound-guided versus palpation-guided corticosteroid injections to the bicipital groove in patients with long head of biceps (LHB) tendinosis.

Materials and methods Forty-four patients with primary LHB tendinosis were randomized into two groups (group A, $n = 22$; group B, $n = 22$). All patients underwent treatment with a single corticosteroid injection to the bicipital groove. Injections in group A were performed under ultrasound-guidance, while in group B using a palpation-guided technique. The duration of each procedure was recorded. To assess accuracy, ultrasound examination was performed in both groups after injection. Patient discomfort was evaluated with visual analogue scale (VAS) for pain. The clinical outcome was assessed comparing the VAS, the Single Assessment Numeric Evaluation (SANE) score and the QuickDASH score before treatment and after 4 weeks and 6 months.

Results The mean duration of the procedure was 64 ± 6.87 s in group A and 81.91 ± 8.42 s in group B ($p < 0.001$). Injection accuracy in group A was 100% and in group B 68.18%. Discomfort was lower in group A, as compared to group B (22.10 vs. 35.50; $p < 0.001$). Symptoms, as measured by VAS, SANE and QuickDASH scores, improved in both groups at 4 weeks and 6 months ($p < 0.05$). Superior clinical improvement was recorded in group A in both time points ($p < 0.05$).

Conclusions Corticosteroid injections are an effective treatment for primary LHB tendinosis. Under ultrasound guidance, injections to the bicipital groove are faster and produce lower discomfort. Superior accuracy and clinical outcomes can be achieved using the ultrasound-guided technique.

Level of evidence Level II; Prospective Randomized Comparative Study.

Keywords Long head of biceps · Biceps tendinosis · Corticosteroid injection · Blind injection · Ultrasound-guided injection

Introduction

The long head of the biceps (LHB) tendon represents a common pain generator that has drawn increasing attention in shoulder treatment. Bicipital tendinosis may result from tendon overuse or degeneration, while impingement syndrome is considered as the most common cause [1]. Primary LHB tendinosis is defined by inflammation of the tendon within the bicipital groove, while secondary tendinosis is associated with other shoulder lesions as rotator cuff disorders, pulley lesions, bicipital subluxation or instability, and superior labral anterior-posterior (SLAP) tears [1–4].

Patients typically complain of a deep-seated, throbbing pain in the anterior shoulder, localized to the bicipital groove. Symptoms may worsen at night, while they may be initiated after repetitive overhead activity, pulling or lifting [2, 3, 5].

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Other manifestations may be also present; as pain towards the insertion of the deltoid muscle or radiating pain down to the ipsilateral hand, sometimes misleading diagnosis [1, 6].

Favorable results from surgical treatment as tenodesis or tenotomy have been reported, however, surgery is the last resort when conservative treatment fails [7–10]. The first line of treatment comprises nonoperative therapeutical means as rest, ice, restriction of overhead activities, nonsteroidal anti-inflammatory drugs (NSAIDs), and physical therapy [1, 2, 6, 10]. Local anesthetic and corticosteroid injections have been advocated as additional treatment options, which may also help to differentiate the origin of shoulder pain [1, 2, 6, 10, 11]. Subacromial injections have been used for concomitant impingement symptoms, while intra-articular injections to the glenohumeral joint (GHJ) may also be beneficial to decrease the intra-articular biceps irritation. Injections directly to the bicipital groove are common for primary LHB tendinosis [6, 10]. The objective of the latter injections is to infiltrate the area within the tendon sheath without penetrating the tendon, as intratendinous administration has been associated with increased incidence of degeneration and rupture [6, 10, 11].

Therapeutic injections have been traditionally performed in a blind fashion, using the anatomical landmarks. However, imaging-guided injections have gradually gained popularity [12–17]. In general, imaging guidance during shoulder injections has been reported to improve accuracy [12, 18], however, differences in the clinical outcome between blind and guided techniques have been questioned [14]. Considering injections for the treatment of bicipital tendinosis, the literature is limited and the preferable injection technique remains obscure. Therefore, we performed this study to compare the accuracy, the patient discomfort, and the clinical outcome of corticosteroid injections to the LHB tendon sheath with ultrasound guidance versus palpation guidance.

Materials and methods

We conducted a prospective, randomized study including patients with anterior shoulder pain derived from primary tendinosis of the LHB. All patients underwent clinical and radiographic evaluation of the affected shoulder, as well as magnetic resonance imaging (MRI). Inclusion criteria comprised tenderness at the bicipital groove during clinical examination and history of symptoms for more than 3 months, refractory to NSAIDs and physical therapy. Patients that had previously received corticosteroid injections were excluded. We also excluded patients with evidence of rotator cuff tear, deposition of calcification, impingement, instability, GHJ deformity or rupture of the LHB tendon at the MRI. Evidence of partial or interstitial LHB tendon tears also consisted exclusion criteria. Thus, 44 consecutive patients (23 men, 21 women; mean age, 42.9 years; range, 25–63 years) were finally enrolled (Table 1). All patients gave written informed consent for their data to be included in this study. The study was approved by the Institutional Review Board/Ethics Committee of the authors' institutions.

Using a computer-generated sequence, the included patients were randomized into two groups. Group A consisted of 22 patients (ten males, 12 females; mean age, 41.5 years; range, 25–59 years) that underwent ultrasound-guided injections, while group B consisted of 22 patients (13 males, nine females; mean age, 43.9 years; range, 29–63 years) that underwent palpation-guided injections. Patients' characteristics between the two groups were similar (Table 1).

All patients were placed in a supine position with the affected arm in neutral rotation. The skin of the anterior shoulder was prepped and draped in a sterile fashion and a diagnostic ultrasound examination was performed prior to the injection in all instances. The ultrasound criteria for normal LHB tendon was that of a hyperechoic and fibrillar structure of uniform thickness; characteristic of normal tendon. Tendinosis was diagnosed when the LHB was abnormally hypoechoic and eventually thickened in relation to the adjacent segments, but without well-defined defects or tendon fiber discontinuity. Full-thickness tears were diagnosed in the presence of complete discontinuity of the LHB tendon, while the presence of an anechoic cleft without tendon discontinuity indicated partial tears. The identification of heterogeneous fluid or variable echogenicity of the synovial tissue surrounding the LHB tendon indicated tenosynovitis [19]. Ultrasound examination, as well as injections in both study groups, were performed by a single operator (CKY); a shoulder surgeon who has extensive experience in shoulder ultrasonography. A conductive water-soluble gel was applied, and the ACUSON S3000™ Ultrasound System, HELX™ Evolution (Siemens, Erlangen, Germany) was used, employing an ACUSON 18 L6 HD linear transducer with operating frequency up to 18 MHz. Patients of both groups received a 10-ml solution in the bicipital groove; 1 ml triamcinolone acetate (40 mg/ml) mixed with 9 ml bupivacaine 0.5%. No prior local anesthesia was applied. To avoid needle bending during insertion and to improve ultrasound visualization, a 4-cm 22-gauge spinal needle was used. The needle was introduced in a 30-degree angle and

Table 1 Patients' demographics

	Group A	Group B
Gender (male:female)	10:12	13:9
Side (right:left)	16:6	14:8
Age (years)	41.5 (range, 25–59)	43.9 (range, 29–63)
BMI (kg/m^2)	29 ± 5.1	26 ± 7.1

Group A = ultrasound-guided injections; *Group B* = palpation-guided injections

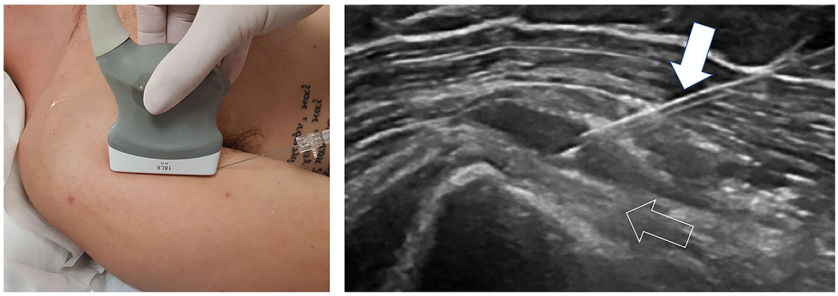

Fig. 1 Ultrasound-guided injection technique in the LHB sheath. The needle (*white arrow*) was introduced in a distal-to-proximal direction, using the in-plane ultrasonographic technique, and 1 ml triamcinolone acetate (40 mg/ml) mixed with 9 ml bupivacaine 0.5% were administered to the LHB tendon (*open arrow*)

the injection was only performed if no resistance was felt (Fig. 1).

In group A, the injection was performed in a distal-to-proximal direction, under direct ultrasound guidance. The long axis of the transducer was parallel to the axis of the needle, producing an in-plane ultrasonographic view of the needle. As such, the needle was constantly visualized during the procedure (Fig. 2), while distention of the bicipital sheath by the injectate was evident. In group B, the bicipital groove was identified by palpation and the injection was performed in a blind fashion, in a distal to proximal direction as well. In order to identify potential inadvertent tendon penetration, after needle insertion the patients were asked to flex their elbow. In the presence of proximal needle movement, needle repositioning was performed.

The duration of the injection procedure was recorded in all instances. In order to assess the accuracy of the injection techniques, ultrasound examination was performed after the procedure, in both groups. Presence of fluid only into the sheath defined accuracy, while accumulation of fluid in the adjacent tissues or in the substance of the LHB tendon was considered as failure (Fig. 3) [20]. The diffusion time of the injected solution was also recorded, performing consequent ultrasound examinations in 10-min intervals.

Patient discomfort during injections was quantified using the visual analog scale (VAS) for pain. All patients with the use of a 10-cm ruler expressed the pain that they experienced marking the distance (in millimeters) between a range of scores from 0 to 100. "No pain" was represented by 0 and "extreme pain" by 100.

The clinical outcome was assessed comparing the status of the patients of the two groups before treatment at 4 weeks and at 6 months after treatment. The VAS for pain (in a similar fashion as in patients' discomfort evaluation [range of scores, 0–100]), the Single Assessment Numeric Evaluation (SANE) score and the shortened Disabilities of the Arm, Shoulder and Hand (QuickDASH) score were recorded before treatment and at each of the two follow-up visits. Complication rates including tendon rupture, vascular injury, and infection between the two groups were also compared.

Data were expressed as mean values ± standard deviations (SD). All study variables followed normal distribution according to the Kolmogorov–Smirnov normality test. Paired sample *t* test was used to compare the differences of numerical values within the groups; before injections and at the different time points, while independent samples *t* test was used to examine the differences of the latter variables between the two groups in the different follow-up examinations. Chi-square test was used to assess categorical variables. The level of significance was set at $p < 0.05$. Statistical analysis was performed using IBM SPSS Software, v.22.0. (IBM Corp., NY, USA).

Results

The duration of the procedure in group A was shorter than in group B (64 ± 6.87 s vs. 81.91 ± 8.42 s; $p < 0.001$). The accuracy of injections was 100% (22/22) in the ultrasound-guided group, while 68.18% (15/22) in the palpation-guided group.

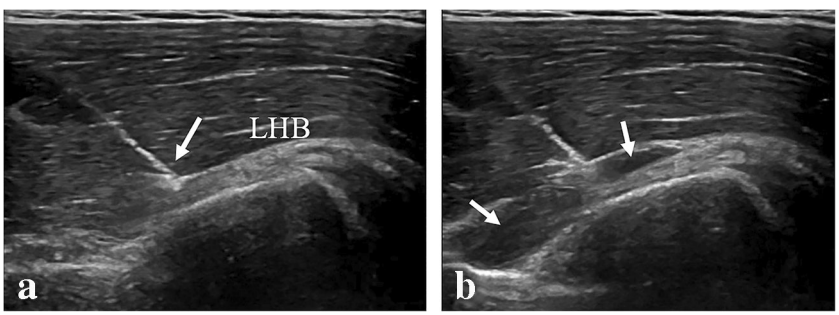

Fig. 2 Longitudinal section of the long head of the biceps (LHB) tendon during ultrasound-guided injection. **a** The *arrow* shows the insertion of the needle into the tendon sheath. **b** The *arrows* show successful delivery of the therapeutic solution within the sheath

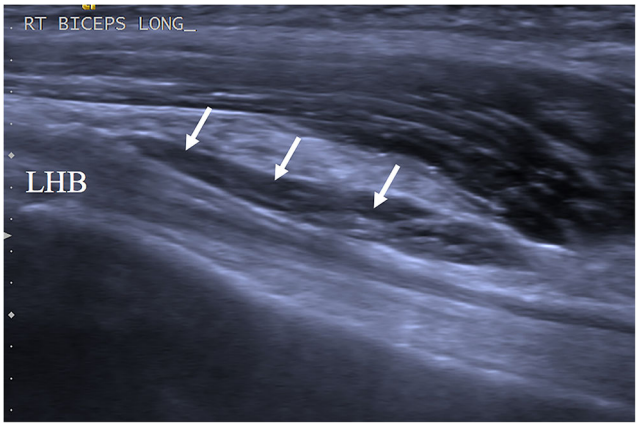

Fig. 3 Picture showing the presence of fluid outside of the tendon sheath, indicating inaccurate injection. *LHB* = long head of the biceps tendon

Inaccurate injections in group B referred to extra-sheath administration; no intratendinous injection administration was identified. In those patients that the injection solution failed to be administered in the LHB tendon sheath, complete diffusion of the solution was recorded within the first 10 min. In the rest of the patients, the mean time of diffusion was 31.1 min (range, 20–40).

Patient discomfort, as measured with the VAS for pain, was found to be lower in the ultrasound-guided group, as compared to the palpation-guided group (22.10 ± 8.70 vs. 35.50 ± 10.10; $p < 0.001$). Patients that experience inadvertent tendon penetration (group A, six patients; group B, 11 patients) reported higher level of pain. Affected side, gender, and BMI were not related to inaccurate injections or inadvertent tendon penetration ($p > 0.05$).

The mean values of VAS for pain, the SANE score, and the QuickDASH score were similar between the groups prior the injections ($p = 0.766$, $p = 0.609$, and $p = 0.630$, respectively), while significant improvement of symptoms was documented in both groups at 4 weeks ($p < 0.05$) and at 6 months ($p < 0.05$) after treatment. The results of all scores were found to be superior in group A, as compared to group B, both at the 4-week ($p = 0.025$, $p = 0.003$, and $p = 0.001$, respectively) and at the 6-month ($p = 0.001$, $p = 0.004$, and $p = 0.010$, respectively) follow-up. However, superior clinical outcome was documented at 4 weeks than at 6 months post-injection, in both study groups ($p < 0.05$) (Table 2). Complications as LHB tendon rupture, vascular injury or infection were not recorded in any patient of the two groups.

Discussion

Shoulder injections are very common in clinical practice. The GHJ, the subacromial bursa, and the bicipital groove represent the usual injection areas. Different approaches may be used, either via palpation of the anatomical landmarks or via image-guided techniques. Some authors postulate up to 90–97% success rates of landmark-based approaches [21, 22] and others question the necessity of imaging guidance to improve the clinical outcome [23]. Nonetheless, many studies support injection guidance via imaging means, as ultrasonography or fluoroscopy [12, 16, 24–26]. Ultrasonography allows direct visualization of the surrounding soft tissues, while fluoroscopy facilitates the injection technique using as reference the bony anatomy and contrast mediums. In general, ultrasound- and fluoroscopy-guided shoulder injections have been reported to provide similar accuracy [26]. However, the use of ultrasound guidance during injections to the bicipital groove is claimed to offer an improved success rate, greater diagnostic capability, and a better cost ratio over fluoroscopy, eliminating radiation and contrast agent risks [25].

In this study, we tried to evaluate the operation of bicipital groove injections for primary LHB tendinosis under ultrasound and palpation guidance. We used ultrasound as a sole post-injection measurer, as it is more cost-effective, more practical, without any radiation or contrast agent risks. We tried to assess whether ultrasound-guided injections are more accurate, and if accuracy is important to obtain a better clinical outcome. To the best of our knowledge, no other study has directly examined injection accuracy and clinical outcome in patients with LHB tendon pathology. We only included patients with primary, isolated LHB tendinosis to eliminate selection bias and avoid any influence of concomitant shoulder disorders to the clinical outcome of injection treatment. We used the in-lane needle visualization approach to perform ultrasound-guided injections. We believe that this technique is faster and more precise, as the needle is inserted parallel to the long axis of the ultrasound transducer facilitating optimal injection control. In the out-of-plane needle placement, only the tip of the needle can be seen, which makes the procedure more difficult. However, the relatively superficial location of the groove makes the latter technique also accomplishable [27].

The results of this study suggest that superior accuracy can be achieved using the ultrasound-guided technique. Performing ultrasound examination after both procedures to our patients, we found 100% accuracy with the ultrasound-guided injections, while 68.18% accuracy with the palpation-guided injections. Consistent with our results, some authors using computer tomography (CT) to assess injection success to the bicipital groove reported improved accuracy of the ultrasound-guided versus the landmark-guided technique (86.7 vs. 26.7%) [13]. Considering that most of the area below the sheath is occupied by the LHB tendon, there is limited space for needle insertion, making safe operation of injections difficult using only the anatomical landmarks [13]. Blind injections may be accomplished easier when the tendon sheath contains fluid, however, when there is no tendon sheath effusion, there is only a 2-mm

Table 2 Clinical scores of the two study groups before treatment, at 4 weeks and at 6 months after treatment

Clinical score	Patients (*n*)	Before treatment (mean ± SD)	4 weeks post-injection (mean ± SD)	6 months post-injection (mean ± SD)	*P* value
VAS					
VAS for pain – group A	22	60.8 ± 14.3	12.6 ± 9.7	16.6 ± 10.3	$p < 0.05$
VAS for pain – group B	22	63.9 ± 11.7	19.8 ± 11.0	27.6 ± 8.3	$p < 0.05$
P value		$p = 0.766$	$p = 0.025$	$p = 0.001$	
SANE					
SANE – group A	22	37.3 ± 18.9	80.0 ± 10.8	65.9 ± 9.7	$p < 0.05$
SANE – group B	22	35.7 ± 16.2	69.8 ± 10.4	57.1 ± 9.8	$p < 0.05$
P value		$p = 0.609$	$p = 0.003$	$p = 0.004$	
QuickDASH					
QuickDASH score – group A	22	48.0 ± 12.2	15.4 ± 8.0	24.0 ± 6.7	$p < 0.05$
QuickDASH score – group B	22	55.5 ± 10.2	23.7 ± 8.1	31.4 ± 5.7	$p < 0.05$
P value		$p = 0.630$	$p = 0.001$	$p = 0.010$	

VAS = visual analog scale, *SANE* = Single Assessment Numeric Evaluation, *QuickDASH* = shortened Disabilities of the Arm, Shoulder and Hand score

space for needle placement [20]. As such, prevention of solution delivery in the tendon or the adjacent tissues is rather uncertain with the blind technique.

In this study, we also observed that ultrasound guidance facilitated faster injection process and lower patient discomfort. The visualization of the soft tissues in real-time ensured accurate needle operation and controlled injection speed, explaining these findings. The more frequent inadvertent LHB tendon penetration, along with a potentially higher rate of punctures during blind injections, may also explain the increased patient discomfort in group B. Even though we did not record the exact number of punctures needed for the injections in each of the study groups, we believe that more than one puncture is unlikely under ultrasound guidance, while repeated punctures are more common during the blinded technique. In this regard, the authors of a similar study reported that a single puncture is needed under ultrasound guidance, while a mean number of 3.6 punctures is needed using blind injections [28]. Additionally, even though we did not find any relation between BMI and inadvertent tendon penetration, in our experience it may be particularly difficult to palpate the bicipital groove in obese or heavily muscled patients during blinded injections.

Efficient clinical outcomes have been demonstrated using corticosteroid injections for the treatment of shoulder pathologies [29, 30]. Some authors postulate that the clinical result relies on the accuracy of injections [24, 31, 32], while others suggest that accuracy is not an important element [14, 33]. In this study, we recorded significant clinical improvement in both groups, evaluating the VAS for pain, the SANE score, and the QuickDASH score at 4 weeks and 6 months after treatment. However, an inferior clinical outcome was documented in the palpation-guided group in both time points. In the latter group, 31.82% of injections failed to be delivered in the bicipital groove, suggesting that injection accuracy influences the clinical outcome in patients with LHB tendinosis. The clinical improvement—even inferior—after inaccurate injections can be attributed to the effect of the therapeutic solution on the sheath, relieving tenosynovitis. However, the complex structure of the LHB tendon sheath and its potential effusion may not allow adequate diffusion of the therapeutic agents to the LHB tendon when they are delivered to the adjacent tissues.

The LHB tendon sheath consists of an anterior recess of the GHJ capsule [27]. The LHB tendon arises from the supraglenoid tubercle and then passes through the GHJ enclosed by a tubular reflection of synovial membrane. This synovial sheath surrounds the tendon as it crosses the intertubercular groove. At the inferior aspect of the groove, this synovial membrane is reflected superiorly to the transverse humeral ligament and the bony part of the groove and courses superiorly to the GHJ synovial membrane [27]. In this respect, part of the injection solution may be dispersed into the GHJ, however we observed that the injection solution was evident in the sheath for a mean time of 31.1 min. This shows that a certain amount of solution remains in the sheath to be absorbed by the tendon. In our study, extra-sheath administration of the injectate resulted in an earlier solution diffusion. We believe that this contributed to a reduced therapeutic effect. Our results are in accordance with those of another study reporting a better clinical outcome after ultrasound-guided corticosteroid injections at a mean follow-up of 33 weeks (range, 25–56 weeks). The authors attributed this clinical difference to the increased accuracy of injections under direct ultrasound visualization, in which the true effect of medication was expected [28].

Even though the symptoms of our patients improved after treatment, a better clinical outcome was observed in 4 weeks than in 6 months. This may be explained with the fact that some patients may develop recurrence of symptoms after a certain period of time. Some authors evaluating the clinical outcome of bicipital groove injections at 4, 12, and 24 weeks after treatment presented similar findings [34]. They reported that corticosteroid injections were effective in improving symptoms at 4 and 12 weeks, however, at 24 weeks some patients complained of pain recurrence, even though they were still symptomatically better as compared to their pre-injection status [34].

In accordance with the related literature [35], we did not observe any complications as vascular injuries or infections in either of our groups. We conducted the injections in both groups in a distal to proximal direction. Under direct ultrasound visualization, the vascular structures can be identified using Doppler and the therapeutic agents can be safely delivered into the tendon sheath. However, palpation-guided injections are conducted in a blinded fashion. In this regard, some authors suggest that placing the needle at the lateral side of the shoulder, and performing the injection in a lateral to medial direction, may prevent vascular injury [28]. Regardless of the chosen technique, it is mandatory that the operator have precise knowledge of the shoulder anatomy and identify the important anatomical structures. Inadvertent penetration of the LHB tendon or injury of the cephalic vain or the ascending branch of the anterior circumflex artery should be avoided [27, 28].

We acknowledge several limitations in this study. First, the number of patients is relatively small, limiting the power of our results. We recognize this limitation, however, in an attempt to minimize selection bias, we only included patients with primary, isolated LHB tendinosis. All other pathologies were excluded to avoid any potential influence to treatment response. Hence, considering that the incidence of primary tendinosis represents only 5–10% of all patients with LHB pathology [1, 28, 36], we believe that the number of the included patients is acceptable. Second, after the injection, some patients might have taken additional analgesics that could influence the clinical outcome. We tried to minimize this influence by reexamining the patients not only at 4 weeks but also at 6 months post-injection. Finally, the documentation of time that therapeutic agents were diffused was not very accurate, as ultrasound examinations were performed in 10-min intervals. However, we believe that important information was extracted from the estimated diffusion time inside and outside the bicipital groove.

In conclusion, corticosteroid injections are an effective treatment for primary LHB tendinosis. Under ultrasound guidance, injections to the bicipital groove can be operated faster with lower patient discomfort, while superior accuracy can be achieved using this technique. Precise delivery of the therapeutic agents into the LHB tendon sheath is important for obtaining an improved clinical outcome.

Compliance with ethical standards

Conflict of interest No benefits have been or will be received from a commercial party related directed or indirectly to the subject matter of this study. The authors declare that they have no conflicts of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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