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ORIGINAL ARTICLE

Treatment of acute acromioclavicular dislocation: suspensory button *versus* double tunnel suture loop

A comparison of clinical outcome and complication rate in 63 patients treated with two different techniques

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ABSTRACT

BACKGROUND: Acromioclavicular (AC) joint dislocation is a frequent shoulder injury. Dozens of surgical techniques have been described but nowadays there is no evidence supporting a specific technique as the gold standard for acute AC joint injury. The aim of the present study was to investigate the difference between suspensory button and double tunnel suture loop techniques in terms of the quality of the acromioclavicular joint reconstruction by comparing functional assessment, clinical scores, and postoperative complication rate.

METHODS: We performed a retrospective comparative analysis of 63 patients treated for acute isolated AC dislocation: 36 treated with suspensory button technique, 27 treated with double tunnel suture loop technique. Surgical time of both procedures was collected and examined. Constant-Murley and DASH scores at 1-year follow-up were compared. The complications such as clavicular fracture, nerve damage, infection and recurrence of dislocation were recorded and analyzed. AC joint displacement ratio was measured on 1-year X-ray considering values greater of 0.5 as recurrence of dislocation.

RESULTS: The statistical analysis did not show any statistical difference of surgical time, Constant-Murley score, DASH score and the complication rate between the two surgical techniques.

CONCLUSIONS: Both techniques ensure a strong and reliable Acromioclavicular repair with satisfactory functional and clinical assessments, so surgical technique choice should be guided by the habit of the surgeon.

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KEY WORDS: Acromioclavicular joint; Joint dislocations; Complications.

Acromioclavicular (AC) joint dislocation is a frequent shoulder injury. It occurs primarily in athletes with an incidence of about 17% of all shoulder traumatic lesions and 30-50% of all sport-related shoulder injuries.[1-4] Patients report falling directly onto the superolateral side of the shoulder with an adducted arm.[5] Rarely, it is caused by indirect trauma to the hand with the elbow in extension.

AC dislocations are classified into six different types according to the Rockwood Classification system, which also dictates the correct management.[6]

Treatment for Rockwood type I and II lesions is conventionally conservative, with immobilization, pain management, cryotherapy, and physiotherapy. The treatment for type IV, V and VI lesions is almost surgical. The indications for conservative versus surgical treatment of type III lesions are debated.[7-9]

Dozens of surgical techniques have been described to treat AC joint dislocations, such as: Weaver-Dunn technique, hook plate, Bosworth screw, Suspensory Button, Suture Loop, etc. These techniques can be generally divided in three groups: Acromio-clavicular stabilizations, coraco-clavicular stabilization, or ligament reconstruction. The procedures could be performed with open, mini-open or arthroscopic approach.[9, 10] Analyzing the biology of the lesions, acute injuries have high healing potential: techniques that maintain reduction and allow tissue healing can be ideal. On the other hand, chronic lesions must be managed with more complex methods such as biologic augmentations, usually with a tendon graft.[11] Nowadays there is no evidence supporting a specific technique as the gold standard for the treatment of acute AC joint injury.

The suspensory button (SB) is a technique based on a system formed by metal buttons and sutures placed between the coracoid and the clavicle that offers the stabilization of the AC joint and strengthens the conoid and trapezoid ligaments. Several articles have demonstrated encouraging radiological and clinical outcomes with a low rate of complications.[12-14]

The double tunnel suture loop (DTSL) is a technique based on two loops of nonabsorbable tapes or threads passed around the coracoid process and through tunnels drilled in the clavicular lateral extremity, in order to ensure the reduction of the joint and the healing of the conoid and trapezoid ligaments. In this technique there isn't any metallic device implanted to maintain the acromioclavicular fixation.

The aim of the present study was to investigate the difference between these two surgical techniques in terms of the quality of the acromioclavicular joint reconstruction by comparing functional assessment, clinical scores, surgical time and postoperative complication rate.

Our hypothesis was that AC reconstruction using the SB and DTSL techniques would lead to comparable results in terms of functional outcome, patient satisfaction, and rate of complications.

Materials and methods

We performed a retrospective comparative analysis of 83 patients treated for AC dislocation from May 2015 to May 2019. The diagnosis of AC joint dislocation was performed according to both clinical and radiological exams. Injuries were graded according to the Rockwood Classification.

Inclusion criteria were patients with traumatic AC dislocation defined as equal to grade III or greater in the Rockwood classification system, surgically treated within 1 month from the time of injury; treatment with the SB or DTSL technique; and a minimum of 1 year of follow-up. Patient with history of shoulder disease (glenohumeral arthritis, clavicular fracture, biceps tendon lesions, SLAP lesions, rotator cuff tear, anterior shoulder instability, adhesive capsulitis), with previous shoulder surgeries, with concomitant injuries, with chronic lesions (more than 1 month between the dislocation and the surgery) and those with less than 1 year of follow-up were excluded (N.=20). The principal targets of this study are the clinical outcomes evaluated using the Constant-Murley rating scale and the DASH Score. The secondary objective is to analyze the developing of different complications. We also compare the mean surgical time spent to complete both procedures. The 63 patients enrolled in the study were chosen to undergo to acromioclavicular surgical repair with SB or DTSL technique, respectively 37 and 26 patients, basing on the on the preference of shoulder specialized orthopedic attending surgeons.

Surgical technique

Under general or regional anesthesia by interscalene block, the patient is placed in a beach chair position with the operative arm placed in a standard arm-holding device. The upper limb is prepared and draped, then coracoid, acromion and clavicle are located and marked with a marking pen.

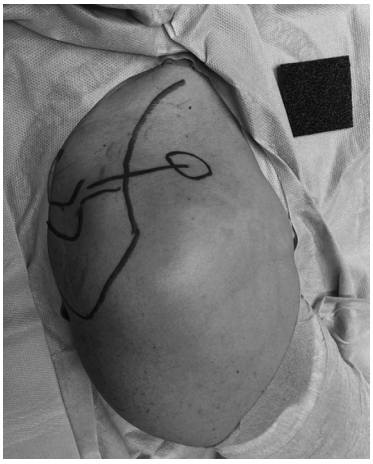

Figure 1.—Patient preparation: patient positioned in beach chair, anatomic landmark and surgical approach marked with a marking pen.

A 6-cm longitudinal skin incision was made in line from the clavicle to the coracoid process (Figure 1), then muscle and soft tissue were dissected up to expose the coracoid process.

Suspensory button

This technique was widely described by Struhl *et al.*,[15] but with some modifications.

A 2.4-mm pin was drilled through the clavicle and coracoid. The clavicle was pierced approximately 3.5 cm medially to the AC joint and in the middle of its anteroposterior diameter. The coracoid was then pierced at its base. With a 4.5-mm cannulated reamer the pin was overdrilled, so the coracoid and clavicular tunnels were made. To restore the anatomy, two additional 1.8-mm tunnels were made 10 mm and 15 mm lateral to the 4.5-mm clavicular tunnel. For this technique, the ZipThight fixation system (Zimmer Biomet, Warsaw, IN, USA) was chosen so the ZipLoop device was passed through the coracoid tunnel and flipped under radioscopic control. The white tiles were excluded for the moment. The remaining sutures were passed through the 4.5-mm clavicular tunnel, then they were tied together on the top of the clavicula using the round button of the ZipThigh fixation system while the assistant pushes over the clavicula to maintain the reduced AC joint. This aims to recreate the conoid ligament. The white tiles are passed through the 1.8-mm clavicular tunnels singularly, then they are tied together on top of the clavicula. This system aims to recreate the trapezoid ligament.

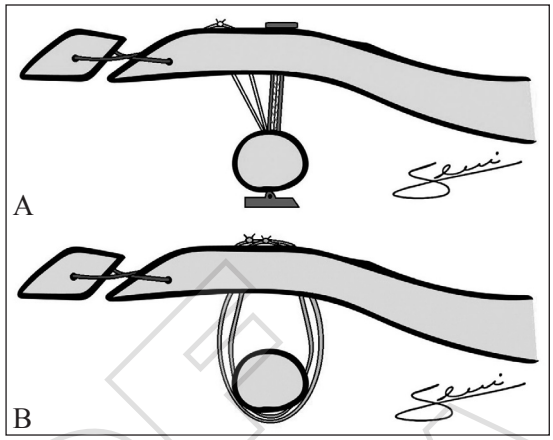

Figure 2.—Surgical technique illustration: A) suspensory button: the tales of the system were passed through two different tunnels to restore the anatomy as conoid and trapezoid ligaments. Furthermore, an acromio-clavicular tension band wiring was performed; B) double tunnel suture loop: non-absorbable tapes were passed around the coracoid without having to drill it. Also in this technique, an acromio-clavicular tension band wiring was performed.

Finally, an acromioclavicular tension band wiring with non-absorbable suture was made (Figure 2A).

Double tunnel suture loop

This technique was widely described by Lädermann *et al.*,[16] but with some modifications.

The AC joint was reduced using a K wire under radioscopic control.

A Deschamps Ligature Needle was passed around the base of the coracoid from lateral to medial, so two non-absorbable sutures such as Mersilene tape (Ethicon, Somerville, NJ, USA), Tiger tape (Arthrex, Naples, FL, USA), Fiber wire (Arthrex), Orthocord (DePuy Synthes, Raynham, MA, USA) were passed through. Preferably the two sutures used are chosen of two different colors to facilitate recognition of the single suture. Using a 2.5-mm pin, two tunnels were drilled over the clavicle from the superior to inferior surface, respectively about 4 and 2 cm to the AC joint. Through both these tunnels a Vicryl suture was passed to use it as a shuttle for the end of the non-absorbable tapes located around the clavicle. The ends of the tapes were tied separately on the top of the clavicula. Fi-

nally, the k wire used to reduce the AC joint was removed.

Finally, an acromioclavicular tension band wiring with non-absorbable suture was made (Figure 2B).

Postoperative rehabilitation

Patients were asked to wear an arm sling for 4 weeks, keeping them on unless for the main meals of the day to move the elbow and wrist; at the end of this period free passive mobilization was allowed. After the 6th week progressive active movements and muscle strengthening were permitted. Patients were recommended to prevent any heavy solicitation for 3 months after surgery.

Postoperative evaluation

The patients were assessed with both clinical exam and radiological evaluation with antero-posterior and Zanca views, at 1, 3 and 12 months postoperatively. At 1 year, clinical examination a shoulder specialized orthopedic collected Constant-Murley, and DASH scores. We recorded all the surgical complications among which loss of reduction, rupture of devices, clavicular fracture, nerve damage, soft tissue damage, and infection. In order to evaluate the loss of reduction, in the 1-year X-ray the AC joint displacement ratio (Figure 3) was calculated: according to Marcheggiani Muccioli *et al.*[17] a ratio greater than 0.5 was considered as a recurrence of dislocation.

Statistical analysis

We conducted the statistical analysis using SPSS statistics software v. 21.0.

A Shapiro-Wilk Test was used to evaluate the normality of the distributions. Continuous variables were compared using unpaired *t*-test or with Wilcoxon Test as appropriate. The chi-square test or Fisher's Exact Test were used to assess the categorical variables. P values <0.05 were considered statistically significant.

Results

Eighty-three patients were treated for AC dislocation, 63 cases were admitted. The average age of the sample was 44.8±15.9 years (range 18-81 years) demonstrating a normal distribution on Shapiro-Wilk test analysis (P=0.49). The patients treated with the SB technique were 36 (57.14%), instead DTSL technique was used to treat 27 cases (42.86%). All the patients were male except for three females (male 95.2%, female 4.8%).

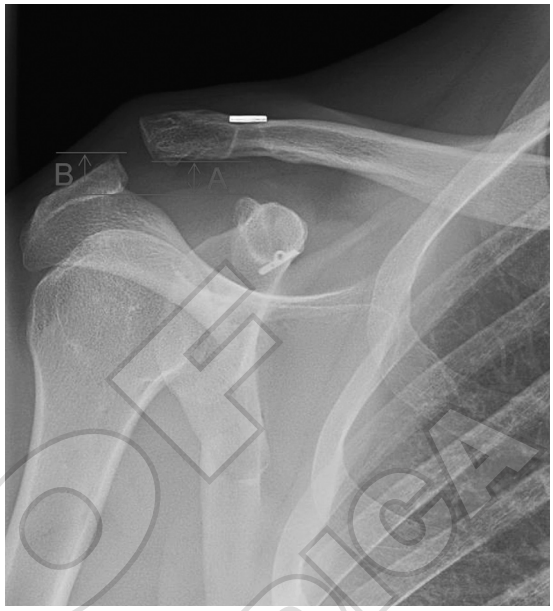

Figure 3.—AC joint ratio: it is the distance from the inferior edge of the acromion to the inferior edge of the clavicle (A)/ acromial height (B); if AC joint ratio is <0.50, we consider loss of reduction.

Thirty-three patients (52.4%) injured the right arm, instead 30 patients (47.6%) dislocated the left AC joint. Dominant arm was affected in 37 cases (58.73%) and the non-dominant arm in 26 (41.27%). No patient was lost during the first year of follow-up. The average time from the dislocation to the surgery was 14.08±8.26 days.

Overall scores average Constant-Murley 93.88±11.33 (range 30-100), DASH 0.95±1.42 (range 0-25). The mean Constant-Murley Score at the final follow-up was in the SB group 93.15 (range 30-100) and in the DTSL group was 94.80 (range 71-100), the mean DASH score in the SB group was 2.5 (range 0-25) and in the DTLS group was 1.67 (range 0-15). The *t*-test we did not show any statistical difference about Constant-Murley Score (P=0.467) and DASH score (P=0.839) between the two techniques.

No complication was reported in 84.1% of patients, while 10 cases (15.9%) had at least one

TABLE I.—*Complication rate relatively to the two surgical techniques in our cohort.*

Complications	Suspensory button	Double tunnel suture loop
Superficial infections	2	1
Implant failure	3	0
Clavicle fracture	0	1
Supraclavear hypoesthesia	1	2
Total	(4/36) 11.11%	(4/27) 14.81%

complication: three superficial infections (4.8%), three nervous lesions (4.8%), three cases of loss of reduction (4.8%) and one case of clavicle fracture (1.6%). The SB treated cohort is average 45.41±15.370 years old, the DTSL cohort is average 44.75±16.221 years old, so there is no statistical difference (P=0.857). Among the patients with loss of reduction, the SB group counted three implant failures (three of 36, 8.3%), while the DTSL group had one case of atraumatic lateral clavicle fracture (one of 27, 3.7%). This latter patient was brought back to surgery and a suspensory button technique with debridement and lateral clavicle resection was chosen. The patient recovered well and regained a satisfactory shoulder function at 1 year of FU. Analyzing the overall complications (Table I), we recorded six complications in the SB group (six out of 36 patients: 16.7%) and four (four of 27 patients: 14.8%), but there is no statistically significant difference (P=0.721). Specifically, we noted superficial soft tissue infection in three patients, two treated with SB technique and one with DTSL technique. These patients were treated with oral antibiotics (amoxicillin/clavulanate 875/125 mg one tablet twice a day for 12 days) and frequent medications with the only result of atrophic scar. Regional hypoesthesia was another complication appreciated in three patients, two treated with DTSL technique and one with SB. They did not have any complaint.

Considering the surgical time, we noted a mean time of 73.01' (range: 45'-105') for SB technique, and 76.36' (range: 45'-120') for DTSL technique, so there wasn't any statistically significant difference (P=0.521).

Discussion

Analyzing the results of the study we can assume that both techniques can yield good functional and clinical results and give a low complication rate. Both the techniques used proved to be safe, effortless, and able to create a stable construct maintaining reduction of the AC joint. In addition, our technique can be considered minimally invasive because of a 6 cm skin incision (Figure 1).

Arirachakaran *et al.* explained in his systematic review how the Coracoclavicular fixation systems, such as suspensory button and suture loop methods present a better postoperative Constant-Murley score in comparison with hook plate to treat acute AC lesions.[18]

Similarly, Darabos *et al.* demonstrated equal radiological and clinical effectiveness between Bosworth screw and Suspensory button method, but the suspensory button grants higher patient satisfaction and a reduced rate of complications.[19]

Many researchers, such as Jensen *et al.* and Andreani *et al.*, detected better results of the suspensory button system compared to hook plate for AC acute dislocation, so they suggest using hook plate only for fracture-separations of AC joint.[20, 21]

Suspensory button system showed biomechanical strength, measured in Newton, equal to or greater than conoid and trapezoid ligaments, according to Walz *et al.*[22]

Hsu *et al.* compared suture loop reconstruction and hook plate and reported superior clinical outcomes of the suture loop, also among patients with radiographic evidence of residual displacement. Suture loops also showed less acromial complications since no metal implants were involved and therefore needed no follow-up surgery for implant removal. On the other hand, in this technique was observed a greater blood loss and a prolonged surgical time was described.[23]

Our double tunnel suture loop procedure is similar to the method described by Hsu *et al.*,[23] with a difference on the clavicular tunnels. In our technique the tunnels are performed on the clavicula from superior to inferior side. In our opinion this method is easier and allows us to better control the tunnels positioning, and it allows us to save minutes, reaching a surgical time comparable to the SB technique.

We prefer to perform two clavicular tunnels according to Jeon *et al.*, since the single tunnel

procedure was associated with more complications following the coracoclavicular ligaments reconstruction.[24]

In the present study comparing Constant-Murley Score and DASH score no significant differences between the surgical techniques were reported. Nevertheless, this data lets us to consider that SB group presents more than twice loss of reduction that the DTSL group. In our opinion it is due to a more uniform strength distribution on the clavicle of the DTSL technique that ensure a reduced enlargement compared to what Jeon *et al.* demonstrated.[24]

From our data we can claim that the Consant-Murley and DASH scores in SB cohort is comparable to those presented in literature as reported in the Ruzbarsky *et al.* systematic review which report a CMS range from 84.4 to 98.2 and a DASH range from 0.375 to 25.2.[25] Similarly, Constant-Murley and DASH scores of DTSL cohort is comparable to Lädermann *et al.* which report a CMS of 96 (ranging from 63 to 100) and a DASH score of 7 (ranging from 0 to 61).[16]

Analyzing the complications, we found one patient treated with DTSL technique present spontaneous lateral clavicle fracture one month postoperative (Figure 4). It is a documented complication which can be explained by tunnel malpositioning. Milewski *et al.* suggested leaving at the minimum 20 mm of space between the two tunnels and placing the most lateral tunnel not less than 10-15 mm medial to lateral clavicular edge.[26] The third lateral clavicle fracture is induced by stress due to tunnel malpositioning.

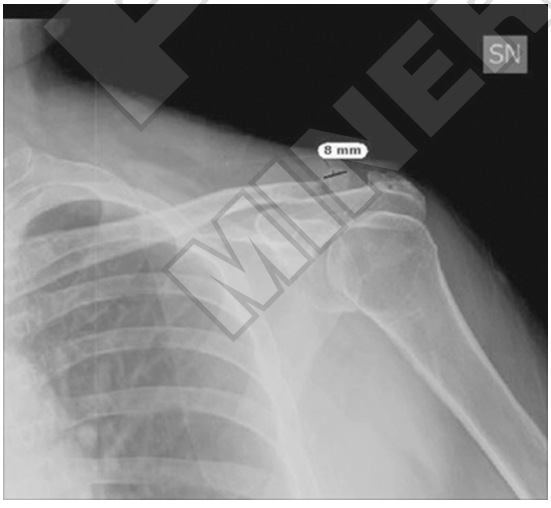

Figure 4.—Clavicular lateral edge fracture in DTSL treated patient: the AC tension band tunnel was made less than 10 mm to the lateral edge of the clavicle.

Measuring on the X-ray, we found a distance between the Acromioclavicular tension band tunnel and the clavicular edge of 8 mm (Figure 4).

We reported three cases of loss of reduction treated with SB technique. Thiel *et al.* report that suture rupture with loss of reduction is the main complication that may occur due to tunnel malpositioning or implant loosening.[27]

It could be explained by the results of Jeon *et al.* reporting how there is a postoperatively enlargement of the bone tunnels, with the risk of failure of the reduction system.[24] In our case series the failure rate was higher in patients treated with SB technique, in contradiction to what was reported in the study of Jeon *et al.* in which, following the enlargement of the tunnels, a higher number of failures was reported in patients treated with Suture loop method compared to Suspensory Button method. We believe that it can be explained by our suture loop technique uses two tunnels and two tapes instead of only one. It results in a more uniform distribution of forces on the clavicle and a better restoration of the acromioclavicular anatomy.

Sun *et al.* proved how the SB failure can be influenced by the angle formed by the position of the Coracoid button and the coracoclavicular line, in fact an angle >20° leads to increased risk of failure due to too much high stress.[28] Analyzing our cases of SB failure, no one present angle >20° so the explanation of the failure has to be found otherwise (Figure 5). Another reason for failure was reported by Motta *et al.* that demonstrated the use of suspensory buttons may not be suggested if the patient presents joint hypermobility. The buttons can immediately stabilize the AC joint in the coronal plane but do not grant stability in the axial plane. As a result, this study assumes that the sutures are disrupted by wear and tear due to the anteroposterior movement of the clavicle generating friction between bone tunnels and the sutures.[29] This is probably the reason for our case series of button failures.

Another difference we noted between the two techniques is about the costs of consumables:

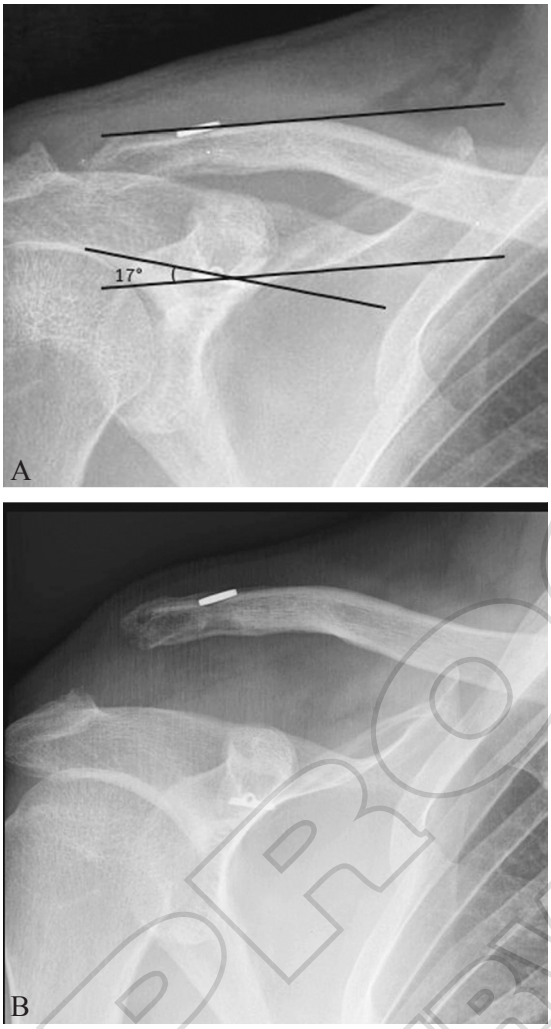

Figure 5.—A) Measurement of Sun *et al.* described angle: the angle between the tangent line to the coracoid button and the coracoclavicular line; B) loss of reduction: although angle is <20°, there was loss of reduction.

according to Marìn Fermìn *et al.*[30] Suspensory Button system is more expensive, € 340±123.7 against a suture tape used in double tunnel suture loop which costs about € 85. On the other hand, the Suspensory Button technique is a more easily reproducible also in inexperienced hand.

Limitations of the study

This study presents many limitations: 1) it was a work based on a retrospective analysis; 2) for this reason, a randomization could not be performed, 3) then the numerosity of the cohort was relatively small. On the other hand, we feel as a positive aspect the standardization of the techniques and the postoperative care that allow to directly compare the results collected at the 1-year follow-up.

Conclusions

We did not find statistically significant differences between the two techniques. Nevertheless, SB technique showed larger costs and higher rate of loss of reduction. To our knowledge, the SB and DTSL techniques ensure a strong and reliable Acromioclavicular repair with satisfactory functional and clinical assessments. We believe that surgical technique choice should be guided by the habit of the surgeon considering the negligible different complication rate of the two procedures.

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Conflicts of interest

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Authors' contributions

Gregorio Secci and Raffaele Tucci have given substantial contributions to the conception or the design of the manuscript. Marco Cocco and Luigi Zanna performed data acquisition, analysis and interpretation. All authors have participated to drafting the manuscript. Matteo Innocenti revised it critically. All authors read and approved the final version of the manuscript.

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