



Case Series

The lateral curved osteotomy for cubitus varus deformity in children: A case report and literature review

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ABSTRACT

Introduction: Cubitus varus deformity after malunited supracondylar humerus fracture has various surgical techniques, implant configurations, and approaches. We describe a combination of French and Dome osteotomy and novel internal fixation technique to deliver an easy, safe, fast and reproducible result based on the current best evidence.

Presentation of case: Two cases of malunited supracondylar humerus are described. The first case involves a 3-year-old girl who presented with outstretched and supinated left arm after falling during bike riding 3 weeks earlier. We found no abnormality in radial and median nerve function, but the left arm radiographs showed a callus formation and the early stages of a malunited fracture of the supracondylar humerus. We waited two months for further radiographic evaluation and the radiographs showed the malunited supracondylar humerus with elbow flexion of only 105° and elbow hyperextension of 20°. The cubitus varus was recorded with clinical carrying angle of varus 10°. We used a combination of original French and Dome osteotomy, lateral approach, and our novel fixation technique with excellent results. The second case involved a 8-year-old boy with malunited right elbow and the surgery was done in the same manner, with the result of restoration to normal elbow range of motion. We also assessed the pain score and disabilities of the arm, shoulder and hand (DASH) score and recorded satisfactory results.

Conclusions: The combination of French and Dome osteotomy for treatment of cubitus varus deformity can provide an easy, safe, and reproducible result.

1. Introduction

The pediatric supracondylar humerus fracture has a high rate of malunion and tend to be malunited overtime. The incidence of pediatric supracondylar fracture was quite high, 5% of all pediatric and adolescent fracture. At the same time, the incidence of malunited of supracondylar humerus that lately was named a cubitus varus deformity varies from 3% to 57% [1]. Several recommendation has been proposed to treat pediatric supracondylar fracture but the result and the strength of evidence was varied. The malunited of supracondylar humerus was described by several component; include elbow varus deformity, elbow hyperextension and internal malrotation [2]. That elbow varus

deformity was the most common complication following the pediatric supracondylar fracture, which the lateral prominence tend to be the main complication after the surgery [3]. Various surgical approach, configuration of osteotomy, and fixation techniques has been studied to correct the malunited of supracondylar humerus and offered good functional outcome without complication. Many recommendations following the treatment of pediatric supracondylar fractures was described with various strength of recommendation. Closed reduction and percutaneous pinning was the most preferred treatment of pediatric supracondylar humerus fracture [4].

French is the name of the orthopedic surgeon in 1959 who found the procedure to treat malunited supracondylar humerus by lateral closed

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wedge osteotomy [5]. He reported a procedure that created a good exposure, easy osteotomy, allow early elbow mobilization and satisfactory functional outcome. The medial cortex of supracondylar humerus was preserved as hinge to promote better healing and additional stability [6].

The purpose of this study is to determine and create the most appropriate, easy and reproducible surgical technique of approach, osteotomy technique, and fixation technique for cubitus varus treatment in children. We also recommended our most of renewed techniques; lateral approach with combination of French and Dome osteotomy, and tension band wire with screw fixation. This study has been reported in line with the PROCESS 2020 (www.processguideline.com) criteria [7].

2. Presentation of cases

2.1. Case 1

A three-year-old girl presented at our center with position of outstretched and supinated left arm due to falling from her bike 3 weeks before. She had no complaints of pain, and eventually was in a good mood and did her regular routine, even though her parents restricted her from performing any sports and high intensity activities such as riding a bike and running. The attending physician ordered the radiographs of anterior-posterior and lateral views of her elbow and the results showed the formation of callus. In the interim, we recommended a reasonable delay in surgical treatment to decrease any complications of surgery (Fig. 1A).

Several radiographs were taken two months later (Fig. 1B) when we diagnosed the patient with malunited supracondylar humerus fracture and planned for corrective osteotomy using a combination of French and Dome osteotomy with our modified internal fixation technique.

2.2. Surgical technique

The procedure was done alone by a 25 years fully experienced orthopedic surgeon. We decided to perform a combination of French and Dome osteotomy by accurately measuring the degree of osteotomy angle. On the preop radiographs, we measured all of the components of the elbow functional angles from clinical and radiographic views. From the clinical assessment preoperatively, range of motion (ROM) of the left elbow were 105° of elbow flexion and 20° of elbow hyperextension, and the recorded clinical carrying angle was 10° of varus. From radiological assessment (Fig. 1), the anterior humeral line showed the capitellum was not intersected with the line that was parallel to the distal one third anterior cortex of the humerus. The carrying angle was carefully assessed by the humerus-elbow-wrist (HEW) angle with the result of 12° varus (Fig. 2).

The imaginary line of the osteotomy site was drawn on the pre-op radiograph and then the surgery was conducted. Intraoperatively, the



Fig. 2. Preoperatively, clinical assessment of the patient with initial ROM of 105° of elbow flexion and 20° of elbow hyperextension, and the clinical carrying angle was at 10° of elbow varus.

lateral approach to the elbow was made with care to prevent iatrogenic injury of the radial nerve (originally, the French osteotomy used a posterior approach while we used Kocher's lateral approach). The bone was exposed on the lateral side and Hohmann's retractor was positioned bilaterally to protect from the danger of neurovascular injury.

We placed two screws, one at proximal and one at distal to the osteotomy site, and both were using a combination of osteotomy techniques according to original French and Dome osteotomy. In addition, we positioned the screws and cerclage wire with our novel techniques, using dual cerclage wire fixation with O's figure and eight's figure (Fig. 3), and the distal screw was posteriorly oblique and the proximal screw was anteriorly transverse (Fig. 4). Finally, we inserted a single Kirschner wire below the distal screw as an antirotation wire. After all of the sequences were done successfully, we called the modified method as Ciamis' osteotomy and fixation technique named after the place of residence of our young patient.

The image intensifier was used intraoperatively before and after the osteotomy and fixation were done with careful decision-making about the best locations (Fig. 4). We made French's lateral closed wedge osteotomy with the guide of screw direction preserving the medial



Fig. 1. A. Initial anterior-posterior and lateral radiographs of the left elbow of a 3-year-old girl showed callus had developed after injury took place 3 weeks before presentation at the clinic. The callus was seen but the healing was not finished. B. Two months later, the radiograph showed significant callus hardening and the patient was diagnosed with malunited supracondylar humerus.

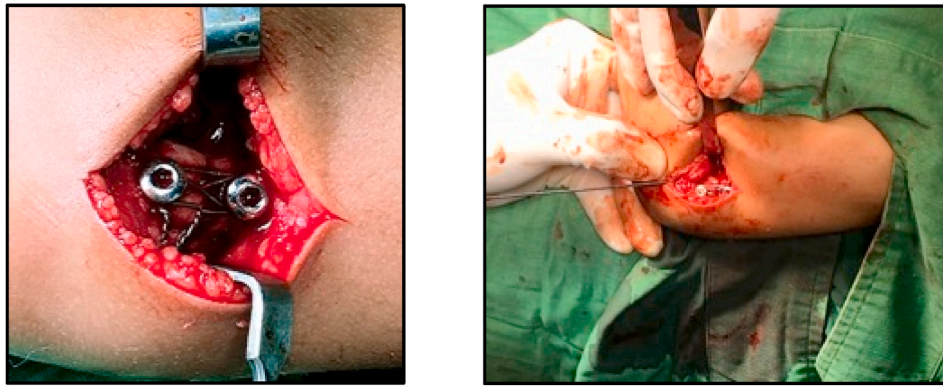


Fig. 3. The O's figure and eight's figure bound both cortical screw after corrective osteotomy was undertaken. Kirschner wire as an optional support was inserted as antirotation while needed.

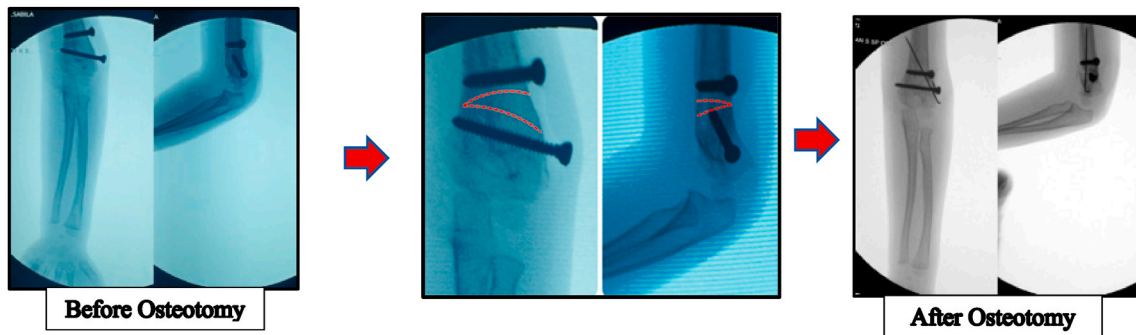


Fig. 4. The accurate measurements of the combination of French and Dome osteotomy were arranged intraoperatively right after the introduction of the proximal and distal screws. The K-wire was used distally to the distal screw to provide antirotation, while the two screws were bound by c-wire with configuration of O's figure and eight's figure.

cortex, by providing a proximal transverse cut and distal oblique cut on the anterior-posterior plane, while we corrected the hyperextension with the same osteotomy within the lateral-medial plane. The French's lateral closed wedge osteotomy was done by an osteotome and the Dome-shaped connections were finished with a rongeur clamp.

The final result was recorded with normal clinical carrying angle, and ROM was also restored to normal range (Fig. 5). The functional

outcome was followed for 3 month after the surgery by ROM measurements, pain score, and disabilities of the arm, shoulder and hand (DASH) score with the following results: elbow ROM of 0–35°, VAS score of 0 and DASH score of 10 which interpreted as excellent result.

The elbow flexion increased by 30° (from 105° to 135), the elbow extension increased by 20° (from 20° hyperextension to 0°), and observed carrying angle (Fig. 5) was improved by 20° (from 10° of varus

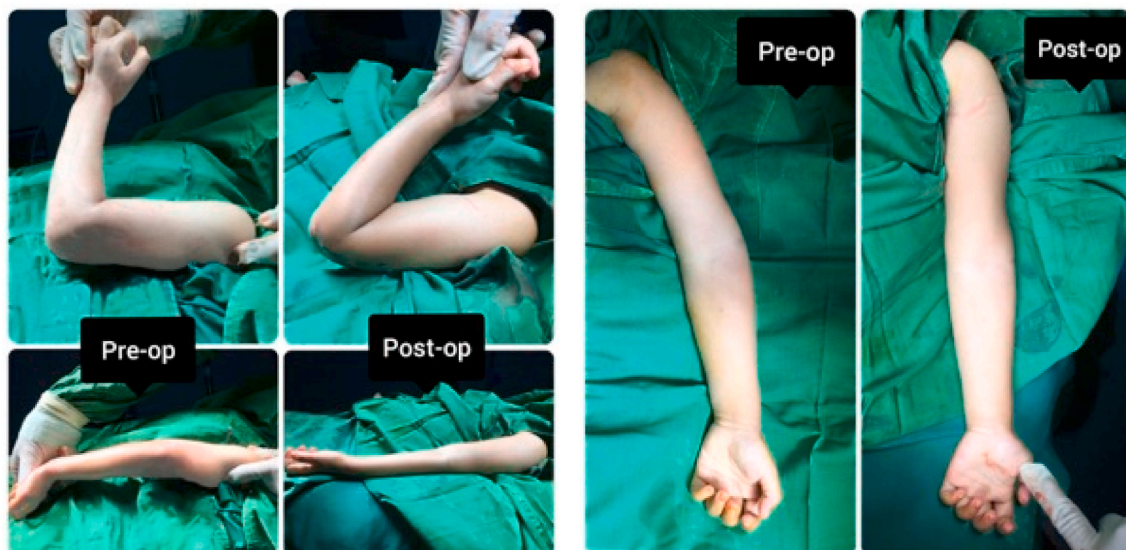


Fig. 5. Post-operative evaluation of ROM. The elbow ROM and carrying angle restored to normal range.

to 10° of valgus). We immobilized the elbow with a back slab in 90° of flexion for 3 weeks. The optimal bone healing was achieved within 3 months. The patient was free from post-operative pain within 4 days, and returned to her favorite hobby, drawing within 2 months.

2.3. Case 2

Our second case reports an eight-year-old boy who presented to our center with malunited right supracondylar humerus with history of falling while playing football about 3 months prior to admission. He was initially treated with open reduction and internal fixation in another institution's pediatric surgery ward with adequate physical therapy to recover his maximum elbow ROM. Eventually, he had no complaints except difficulty in eating with his right dominant hand. Our physical examination results showed only 95° of left elbow flexion and the carrying angle was 11° while in comparison, his left elbow has 18° of carrying angle (Fig. 6A). The initial anteroposterior and lateral radiographs of his right elbow showed the pathognomonic indication of malunion of the supracondylar humerus: the anterior humeral line did not intersect one third anterior of the capitellum on true lateral radiographs. The decision-making process began with the parents' informed consent to attempt the surgical correction to his right hand and arm along with the assent from the patient.

We decided to perform the same technique of fixation as in the case one: using the lateral approach, combination of French and Dome osteotomy, and Ciamis' osteotomy and fixation technique (Fig. 7). Following the successful surgery without complications, we immobilized the elbow using a back slab with 90° of elbow flexion for 3 weeks, then the back slab was removed and the patient started the rehabilitation protocol with gentle ROM exercise. The post-operative radiographs show the screw placement on anteroposterior and lateral radiographs (Fig. 8). The functional outcome was followed for 3 months after the surgery by ROM measurements, pain score, and DASH score with the following results: elbow ROM of 0–124°, VAS score of 0 and DASH score of 16.

3. Literature review and discussion

The presentations of the malunited supracondylar humerus in children were described as the appearance of abnormality of elbow ROM with restricted elbow flexion and excessive elbow extension, and the component of malunited internal rotation of distal fragment. The incidence of cubitus varus following malunited supracondylar humerus is notably high, about 10–50% [8,9]. The main complaints of most

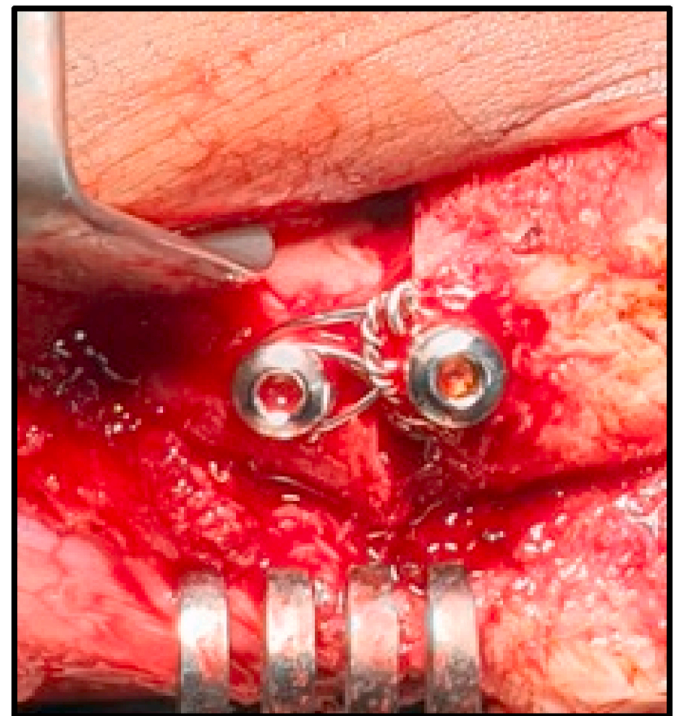


Fig. 7. The two cortical screws 3.5 mm was placed at proximal and distal to osteotomy site, and locked with O's figure and eight's figure using cerclage wire size 1.0.

children's parents are to improve the appearance of the elbow and to correct the limited function of the hand involved in eating and touching their own head for brushing teeth, washing and combing their hair [9].

The development and modifications of surgery techniques of cubitus varus deformity correction are numerous. While no current evidence clearly describes the comprehensive surgical sequences of the corrective osteotomy at the supracondylar humerus, French et al., in 1959 performed corrective osteotomy of the cubitus varus, and Dome osteotomy was described by Kanaujia et al., in 1988 [5,10]. The improvement of the techniques is still developing until now, whereas biomechanical analysis of implant configuration using the three-dimensional imagery of the distal humerus is still in development [8,9,11].

Our osteotomy technique is based on the lateral closed wedge

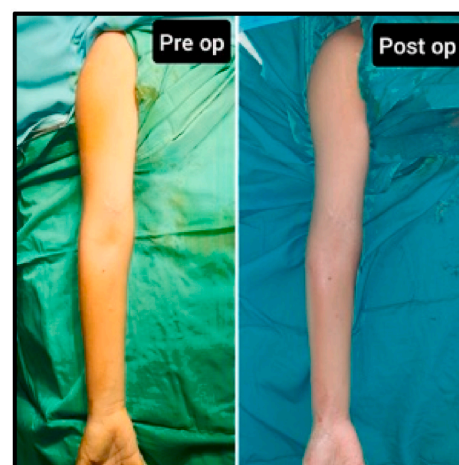
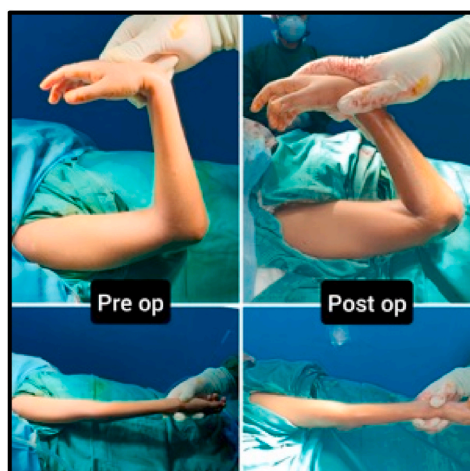


Fig. 6. Preoperatively, clinical photo of the second case: initial range of motion 95° of right elbow flexion and 0° of elbow extension, while clinical carrying angle was 11° of valgus (compared to his left elbow which was 18° of valgus). Post-operative clinical photo showed the improvement of elbow flexion to 124° and the restoration of carrying angle to 16° of valgus.

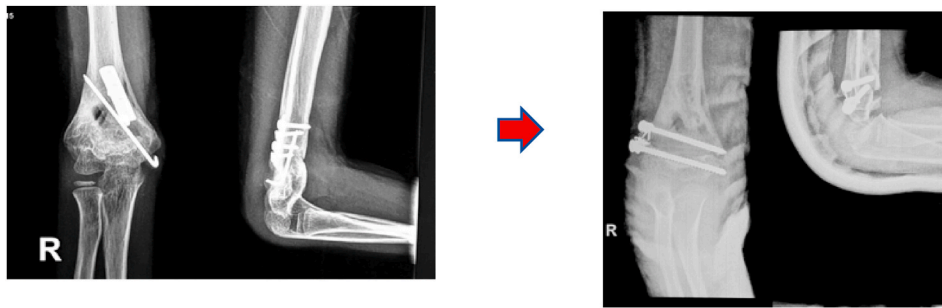


Fig. 8. The anteroposterior and lateral radiographs were taken preoperatively and postoperatively. We performed implant removal, combination of French and Dome osteotomy that later we called Ciamis' osteotomy, along with Ciamis' fixation technique.

osteotomy by French combined with Dome osteotomy, that provides an easy, stable and reproducible result [12–15]. The medial open wedge osteotomy is now not recommended since it can lead to instability and elongate the course of ulnar nerve with the risk of late onset of tardy ulnar nerve palsy [14]. The various surgical techniques are well-described in three major features: approach of the elbow, configuration of osteotomy, and fixation technique [12–15].

1. Approach of the elbow: Lateral [12,13,15–17], posterolateral [10, 18], posterior (triceps splitting) [3,19–21], and posterior approach with Chevron's osteotomy [19].
2. The configuration of osteotomy was described by many literatures, that bear various names on its techniques: French [5,22,23], Dome-shaped [10,19,21,24], Pentalarateral [16], translation step cut

[3], modified step cut [2], triple modified French [12], reverse V [20], dual planar [25], and multiplanar [17], lateral closing isosceles triangular [15], three-dimensional printing assisted [26], and oblique lateral closing-wedge [13]. They mostly provide similar advantages but with different outcome evaluations. The comparison of these surgical techniques is often described equally, reporting similar good results with several advantages and disadvantages [4,17].

3. Fixation technique: Cortical screw then tension band wire [5,12,18], K-Wire only [2,10,13,18,21,24,27], single Y plate [3,20], K-wire then lag screw parallel [16], buried smooth K-wire [25], two lateral K-wire [15], and 3D printing osteotomy guide plate [26].

We reviewed current available studies regarding these surgical techniques and collected relevant important data as reflected in Table 1.

Table 1
Review of related osteotomy literature.

Series	Total patients	So-called techniques	Mean age (years)	Type of studies	Mean Follow-up (Month)	Results	Complication rates
Kanaujia et al. [10].	11 elbows (11 patients)	Dome Osteotomy	9.0	Cohort prospective	61	Restored all carrying angles to normal	0% (No ulnar nerve palsy)
North et al. [23].	90 elbows (90 patients)	French osteotomy	8.2 years	Cohort retrospective	4.8	Restored all carrying angles and ROM to normal	3 patients with poor result (>20° of loss pre-operative ROM) 2 patients with hyperextension with flexion to only 110°
Kim et al. [3].	17 elbows (17 patients)	Translation step cut osteotomy	25.0	Cohort retrospective	28.2	Oppenheim criteria were excellent Mean final DASH value and MEPS were good	One case had delayed union One case had transient radial nerve injury
Laupattarakasem et al. [16].	57 elbows	Pentalateral osteotomy	14.0	Cohort prospective	16.1	Restored all carrying angles to normal and no change in arc of movement	3 patients had loss of fixation in operated elbow without splinting 3 patients refused further surgery and had residual varus deformity of 20° 2 patients still had lazy S deformity caused by an error in osteotomy No significant neurovascular or infective complications
Kumar et al. [22].	25 elbows (25 patients)	13 patients of French osteotomy and 12 patients of Dome osteotomy	10.0 years	Randomized study	12.0	Carrying angle correction was not statistically different between two groups Baumann's Angle was not statistically different between two groups Rotational deformity was greater in dome osteotomy Overall, French was superior to Dome	In French osteotomy group, there were 2 patient with inadequate correction, and 2 patients with loss of motion In Dome osteotomy group there were 1 patient with infection, 1 patient with inadequate correction, 1 patient with nerve palsy, 5 patients with loss of motion, and 1 patient with vascular complication
Su et al. [15].	25 elbows (25 patients)	Triangular osteotomy	9.5	Cohort prospective	3.4	Restored all carrying angles to normal	3 patients had pin site infection 4 patients had extensive scarring None had evidence of nerve injury.

Our novel technique performed corrective osteotomy as described separately in both lateral closed wedge osteotomy by French et al. [5]. and Dome osteotomy by Kanaujia et al. [10]. Although several studies comparing both French and Dome techniques were reported, there is still some controversy about what is the best type of osteotomy to be used with which approach and fixation technique [22]. The incision of the original French method was described as a posterior approach, while our technique used Kocher's lateral approach, which subperiosteally exposed the bone by anterior, lateral ridge, and posterior cortex. The difference of the internal fixation technique was precisely decided due to the inferiority of the old techniques that only use single tensioned wire to bind the screw without Kirschner wire for antirotation wire [9].

The complications of supracondylar osteotomy were studied in some literatures. Raney et al. [28], divided the complications into the overall complications, fixation techniques, and approaches. In 23 patients, there were four major complications: ulnar nerve palsy (13%), loss of reduction (4%), non-union (3%), and lateral condyle prominence (3%), while reoperation was needed in 8 of the 23 patients. Eventually, higher loss of reduction was reported with only Kirschner wire fixation [28]. The posterior approach has a higher incidence of nerve palsy compared to none with the lateral. The poor result of supracondylar osteotomy is because of under correction or persisting cubitus varus deformity and limitation of ROM [19]. Lateral condyle prominence could be prevented by the Dome-shaped osteotomy with excellent cosmetic outcome [29].

The weakness of our report is only two cases are reported demanding more research to confirm our results, even though modifications of our novel technique have been applied to more than 20 patients with excellent outcomes without major complications. Even so, the less technically demanding methods and fewer instrumentation of our procedure demonstrate the advantages compared to the other procedures. The understanding of three-dimensional anatomy of the supracondylar humerus and the malunited feature are crucial to achieve the best quality of reproducible corrective osteotomy of cubitus varus deformity.

4. Conclusions

The combination of French and Dome osteotomy for treatment of cubitus varus deformity can provide an easy, safe, and reproducible result.

Disclaimer

No patient or author details are included in the figures.

Declaration of competing interest

The authors declare no conflict of interest.

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No source of funding.

Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of written consent is available for review by Editor-in-Chief of this journal on request.

Ethical approval

This Ethical Approval from medical and health research ethics committee, faculty of medicine, public health and nursing, Universitas Gadjah Mada.

Author contribution

Iman Solichin, Gede Sandjaya, Ido Prabowo, Nurmansyah Hata Dwi Putra, Sholahuddin Rhatomy:

- conceived the study.
- collected data.
- Analysed data.
- Prepared and drafted the manuscript, edited manuscript and reviewed the manuscript.

Trial registry number

1. Name of the registry: research registry
2. Unique identifying number or registration ID: researchregistry6669
3. Hyperlink to your specific registration (must be publicly accessible and will be checked): <https://www.researchregistry.com/registry/60544cdb567434001b1a6dfd/>

Guarantor

Sholahuddin Rhatomy.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.amsu.2021.102315>.

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