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Case report

Treatment of elderly comminuted proximal humeral fracture using endosteal anatomical support system: A case report

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ABSTRACT

Introduction: Intramedullary anatomical medial strut with allograft bone (IAMSAB), which accommodates the shape of the proximal humeral cavity and provides rotational stability and direct support to the medial column, was successfully introduced to augment Lateral locking plate (LLP) in the treatment of elderly comminuted proximal humeral fractures. Based on the LLP-IAMSAB construct, a newly titanium endosteal anatomical support system (EASS) was developed.
Case presentation: Reported here is a single case of a highly comminuted proximal humeral fracture. The fractures were treated with EASS. The patient's fracture healed properly. The 24-month follow-up demonstrated no pain and a good functional outcome, with no signs of reduction loss, absorption of greater tuberosity, varus displacement and avascular necrosis of humeral head.
Clinical discussion: The newly developed EASS had several special considerations contributing to satisfactory surgical outcome. The flat plane construct of the proximal end of the EASS directly support humeral head to prevent varus displacement of the humeral head, instead of the purchase between the screw thread and the cancellous bone inside the humeral head in the nail or plate fixation. Medial anatomical shape of proximal end helps to reduce medial cortex reduction. Greater tuberosity support block with rotator cuff suture fixation might promote greater tuberosity healing and prevent its absorption. However, there is no similar construct in the nail or plate fixation.
Conclusion: The newly developed endosteal anatomical support system might be a promising option in the treatment of elderly comminuted proximal humeral fractures. Although the effectiveness of this system requires additional evaluation upon more patients being treated with this surgical method, the newly developed EASS may serve as a humeral head-preserving method for elderly patients with comminuted proximal humeral fractures.

1. Introduction

Proximal humeral fractures (PHF) account for 6 % of all fractures and are the third most common fracture in elderly osteoporotic fractures [1]. Among these fractures, only severely displaced, comminuted complex proximal humeral fractures are selected for surgical treatments. Although lateral locking plate (LLP) gained popularity over these years, post-surgical complications, such as varus displacement of humeral head and screw cutout, often emerge, due to lack of medial cortical buttress from fracture comminution, severe osteoporosis, enlargement of the proximal medullary cavity, and rotator cuff lesions [2–5].

LLP and endosteal strut was advocated to treat severely comminuted complex proximal humeral fractures [6–10]. However, this approach is technically challenging due to uncertainties regarding the geometry of the intramedullary cavity and the placement of the strut. Intramedullary anatomical medial strut with allograft bone (IAMSAB), which accommodates the shape of the proximal humeral cavity and provides rotational stability and direct support to the medial column without extensive soft tissue stripping or damage to the medial hinge, was introduced to augment LLP [11]. Biomechanical study [10] shows that compared to endosteal strut, LLP-IAMSAB provides better direct medial support of humeral head and resistance to rotation when used with LLP.

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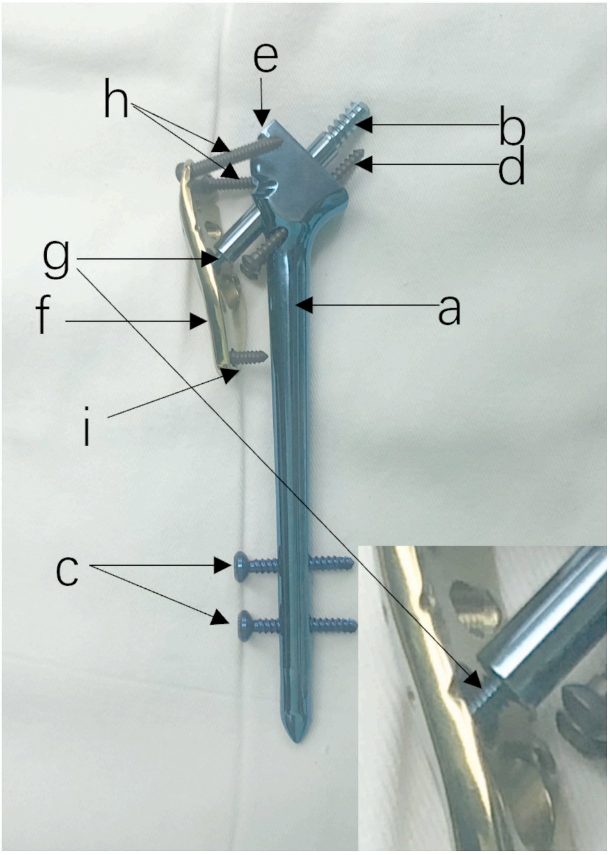

Fig. 1. The new endosteal anatomical support system (EASS) It is composed of endosteal anatomical support nail (a), 6.5 mm cannulated screw (b), distal interlocking screw of the nail (c); anti-rotation screw (d), Greater tuberosity support block (e), small plate (f), Lag screw (g), Proximal locking screw of the plate for fixing tuberosity (h), and distal screw for fixing small plate to humeral shaft (i). The foregoing alphabetical order indicates the order of application during surgery.

The newly titanium endosteal anatomical support system (EASS) (Tianjin Walkman Biomaterial Co. Ltd., Authorized Patent Number: CN201410342347.4, JP2017-520350A, EP3170465A1) was developed based on the LLP-IAMSAB construct to solve the problems of allograft bone, such as minor immunogenic rejection and risk of disease transmission [14]. This system includes three specific titanium parts (Fig. 1): ① a novel endosteal anatomical support nail (a), which not only provides direct support of the humeral head but also accommodates the shape of the medullary cavity of the proximal humerus to correct displacement of medial hinge [5,10–12], ② a small plate (f), which provides suture point for the rotator cuff, and ③ a greater tuberosity support block (e), which directly support greater tuberosity from intramedullary cavity.

This is the first clinical case report of an elderly patient with a comminuted proximal humeral fracture treated with EASS. Our case illustrated its novel application with a successful short-term result. The patient was informed that data concerning the case would be submitted for publication, and she provided consent. The work has been reported in line with the SCARE criteria [13].

2. Case report

A 74-year-old woman with a medical history of osteoporosis and hypertension presented to the hospital after a fall directly onto the right shoulder 3 days prior. Radiographs and urgent computed tomography (CT) demonstrated a 3-part valgus PHF (OTA/AO 11-C1) with substantial humeral head displacement and the humeral shaft impacted into humeral head (Fig. 2). No neurological deficits were noted during clinical examination, and the patient has neither previous injury nor surgery to her right shoulder.

The surgery was performed on the patient 9 days after the injury by two senior surgeons (****). *** has 20 years of clinical experience in orthopedics. Under general anesthesia, the patient is placed in a semi-beach-chair position. Intraoperative fluoroscopy is used to obtain anterior-posterior and axillary images. A standard deltoid splitting approach gains access to fracture site. To reduce the position of the greater tuberosity and the lesser tuberosity, we use ethibon #2 sutures at the rotator cuff insertions of each tuberosity, bringing both tuberosities closer towards one another.

Through the opened lateral fractured window of the proximal humerus, the lamina spreader is inserted between the humeral head and humerus shaft. By opening the lamina spreader, the humeral head is raised to realign with the tuberosities, and the shape of the proximal humerus is restored (Fig. 3a-c). Subsequently, the distal end of the endosteal support nail is inserted into the intramedullary cavity of the humeral shaft to an appropriate depth (Fig. 3d). Using an elevator, we reduce the humeral head position, creating space for the proximal end of the endosteal support nail to enter the medullary cavity (Fig. 3e). Once the entire endosteal nail is inside the humerus, we use aiming tools to adjust the position of the proximal end of the endosteal support nail into directly supporting the humeral head and aligning the humeral head and

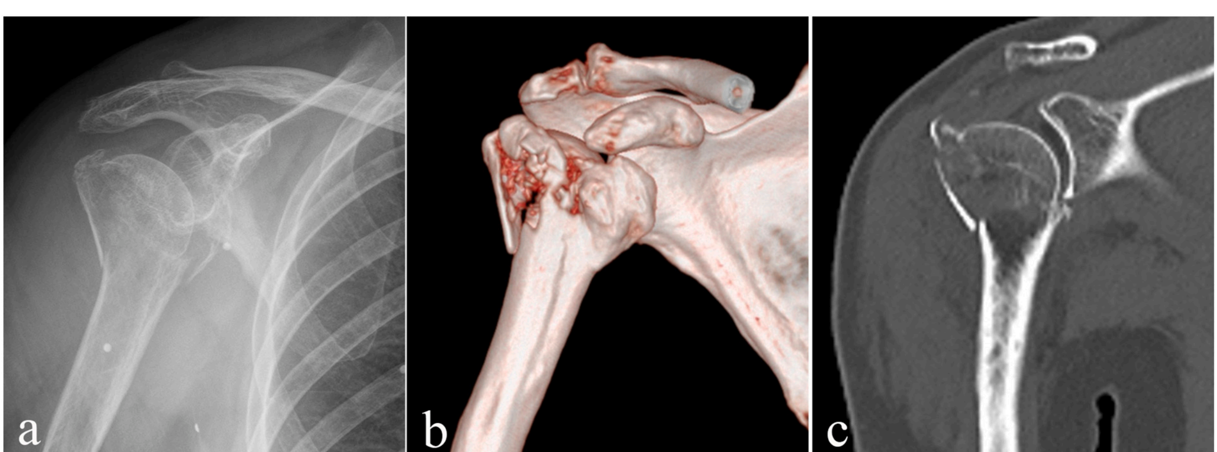

Fig. 2. Female, 72 years old with Neer 3-part valgus fracture of proximal humerus. a. Anterior-posterior X-ray. b. CT three-dimensional reconstruction image. c. Sagittal CT image.

Fig. 3. Intraoperative fluoroscopy during surgical fixation procedure using Endosteal Anatomical Support System (EASS) a. Anterior-posterior view of shoulder joint shows Neer 3-part valgus impacted fracture of proximal humerus. b-c. Laminar spreader is inserted to help to restore the humeral head height and glenohumeral joint. d. Insert the nail into the medullary cavity of the humeral shaft at a suitable depth. e. Using periosteal elevator to reset the humeral head. f-g. inserting the guide wire to the center of the humeral head in anterior-posterior and axillary view. h-i. After the operation, the new EASS was used to fix the proximal humerus.

shaft while monitoring real-time fluoroscopy of anterior-posterior and axillary view (Fig. 3f-g). Once the endosteal support nail is positioned correctly within the humerus, a trocar assembly is inserted through the aiming arm, orienting towards the center of the humeral head. After positioning the drill sleeve at the center of the humeral head, the guide wire is driven into the humeral head through the proximal end of the endosteal nail. Following the guide wire, a 6.5 mm canulated screw with the appropriate length is driven into the humeral head, 5 mm underneath the subchondral bone. Once the overall shape of posterior medial structure of the proximal humerus is restored, we continue to complete monoplanar locking at the humeral shaft by inserting two appropriate length 4.0 mm interlocking screws through the distal end of endosteal nail. Upon completion of installation, the aiming arm is disassembled, and the appropriate greater tuberosity support block is inserted into humeral head to fill in the space left by the aiming arm. Fasten the ethibon #2 sutures at the rotator cuff insertions of each tuberosity, bringing both tuberosities together. Align small plate properly to the humeral shaft, and the lag screw is inserted into the 6.5 mm lag screw through the small plate. Using 4 3.5 mm locking screw through small plate to fix tuberosity and then using a 3.5 mm screw to fix small plate to the humeral shaft (Fig. 3h-i). To resist the tension of rotator cuff, we use ethibon #2 sutures to create three sets of cerclage stiches that suture the rotator cuffs of the tuberosities to the holes in the small plate.

3. Surgical outcome

The patient was discharged home on the third day after surgery without detectable post-surgical complications. The patient began active and assisted range of motion of shoulder the next day after the surgery.

Three months after the surgery, she began progressive active exercising. Bone healing at 3 months postoperatively was confirmed by X-ray and 3-dimensional computer tomography reconstruction (Fig. 4) and the

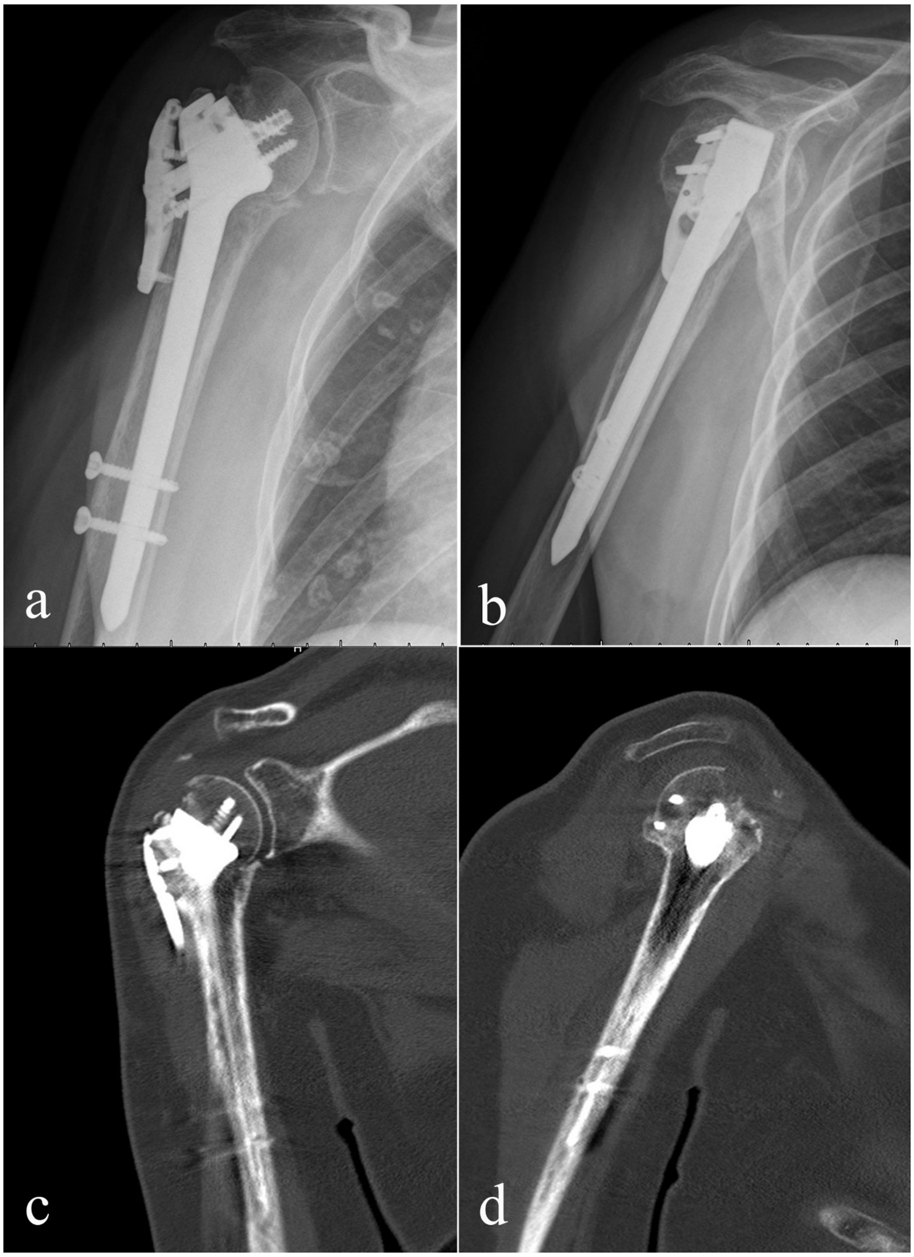

Fig. 4. Radiation and three-dimensional CT at the 3 months follow-up confirmed that fracture healed and **EASS** position was reliable. a.b. Fracture healed, with neck-shaft angle of proximal humerus 137 degrees, no signs of AVN. c.d. Sagittal and coronal CT view of proximal humerus showed that bone trabecula pass through the fracture site, with direct support of the humeral head from the flat plane construct of the proximal end of the endosteal support nail and of greater tuberosity from support block.

Table 1
The patient's shoulder function at follow-up.

	3 months	6 months	1 year	2 years
Constant Murley score	59	65	78	85
Active elevation (degrees)	90	130	140	150
External rotation (degrees)	20	40	45	45
Internal rotation to	Front pocket	Back pocket	The waist	12th thoracic vertebra

patient's shoulder function was evaluated using Constant Murley score (Table 1). At last follow-up of 2 year, the patient was able to perform all activities of daily living and participate in recreational activities. She will continue yearly follow-ups. There was excellent pain control and no sign of instability or any complications with the implant (Fig. 5).

4. Discussion

The case report shows the effectiveness of the newly developed EASS in treating elderly comminuted proximal humeral fracture, which might point out clear direction for multicenter clinical research. The ultimate surgical outcome proves to be satisfactory after patient's fracture healed properly and regained full shoulder function without any post-surgical complications including screw perforation, varus displacement and avascular necrosis of humeral head. Several advantages of the newly developed EASS over the intramedullary nail or locking plate fixation method possibly contribute to the new instrument's satisfactory surgical outcome.

First, in the newly developed device, varus displacement of the humeral head is prevented by the direct support of the humeral head from the flat plane construct of the proximal end of the endosteal support nail. The plane was 45 degrees comparative to the axis of the humeral shaft and 6.5 mm cannulated screw and lag screw provide the primary stability between the humeral head and the support plane. However, in the

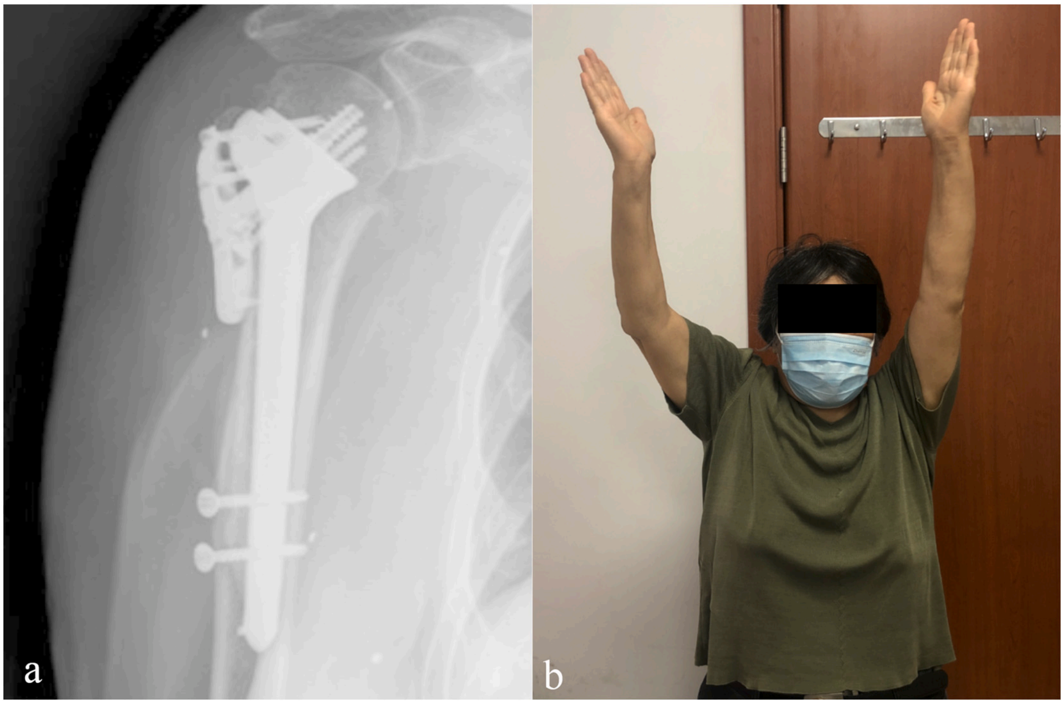

Fig. 5. At 2-year follow-up, the patient was able to perform all activities of daily living and participate in recreational activities. There was excellent pain control and no sign of instability or any complications with the implant. a. X-ray film; b. Function of active elevation.

nail or plate fixation, varus displacement of the humeral head is prevented by the purchase between the 3.5 mm screws thread and the cancellous bone inside the humeral head, which was poor for the elderly patient because of osteoporosis.

Secondly, continuity of medial cortex can be aligned automatically when the endosteal anatomical support nail was placed through fractured lateral windows of proximal humerus, including greater tuberosity and lesser tuberosity because medial shape of the proximal end of the nail was compatible with medial side of medullary cavity. However, in the nail or plate fixation, no construct produced similar function.

Thirdly, greater tuberosity support block and rotator cuff suture fixation might promote greater tuberosity healing and prevent its absorption. Greater tuberosity support block could directly support greater tuberosity from intramedullary cavity and help to reduce greater tuberosity. Rotator cuff was secured on the hole located on the plate using unabsorbable suture, which resist the tension from rotator cuff and prevent greater tuberosity from be pulling and shifting. However, in the nail or plate fixation, no construct produced similar function.

5. Conclusion

In summary, the newly developed endosteal anatomical support system is a promising surgical option for treating elderly comminuted proximal humeral fractures. Although the effectiveness of this system requires additional evaluation upon more patients being treated with this surgical method, the newly developed EASS may serve as a humeral head-preserving method for elderly patients with comminuted proximal humeral fractures.

Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request. No identity identifiers are present whatsoever in the manuscript.

Author contributions

Hua Chen wrote the paper, Zuhao Chang and Zhengguo Zhu collect the information and follow up of the patient; Hua Chen and Peifu Tang performed the surgery; Z. Chang and Z. Zhu joined the surgery; P. Tang revised the paper; H. Chen, Z. Chang and Z. Zhu contributed equally to this work.

Ethical approval

This study was approved by the ethics committee of Chinese PLA General hospital (301 Hospital) (S2020-011-01).

Registration of research studies

This study was registered on Chinese Clinical Trial Registry chictr.org.cn (ChiCTR2000038167).

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Guarantor

Chen hua, M.D. and Tang Peifu, M.D.

Provenance and peer review

Not commissioned, externally peer reviewed.

Declaration of competing interest

The authors declare no conflict of interest regarding the publication of this article.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijscr.2022.107823.

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