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Case series

Reconstruction of intraarticular distal radius malunion with 3D printed guide and arthroscopic assisted intraarticular osteotomy

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ABSTRACT

Introduction: Distal radius fractures are one the most common upper extremity injuries, accounting for 25 % of pediatric fractures and up to 18 % of elderly fractures. Intraarticular malunion is one major complication of distal radius fractures and was reported in 0 to 33 % of total cases. It usually causes pain, deformity, limited range of motion (ROM), and loss of strength. Therefore, proper surgical management to satisfactorily unite the fragment is necessary.

Case Illustrations: This is a case series of three adult male and female patients diagnosed with intraarticular distal radius fracture with malunion. They had been diagnosed based on clinical and radiological examinations. Preoperative and postoperative QuickDASH and ROM were measured. Three-dimensional printing was created for planning the osteotomy. Osteotomy was performed using arthroscopy. All patients showed QuickDASH and ROM improvement in all wrist movements.

Discussion: The primary goal of the procedure was to restore normal anatomic alignment to improve wrist function and reduce pain. Osteotomy guided by arthroscopy planned by 3D printed surgical guide successfully reduced the malunion fracture.

Conclusion: Osteotomy assisted by arthroscopy combined with the 3D-printed surgical guide is a promising technique to restore challenging intraarticular distal radius malunion.

1. Introduction

Distal radius fractures account for 15 % of all fractures and 75 % of forearm fractures [1,2]. One major complication of distal radius fractures is malunion, which can be intra-articular or extraarticular. This condition is treated with fracture repositioning and position maintenance with cast immobilization and internal or external fixation. However, unreduced or unrecognized fractures result in malunion, arthrosis, and functional decrease of the forearm, wrist, and fingers [2]. Distal radius malunion alters biomechanics by decreasing radial inclination, decreasing DRUJ space, increasing volar or dorsal tilt, and increasing the intraarticular gap. Reduced radial inclination changes the position of the carpal tunnel and the angle of the flexor tendons, resulting in decreased grip strength. DRUJ space reduction affects load transmission, forearm rotation, and DRUJ pain. To treat neglected distal radius fractures, an osteotomy is frequently required to realign the radiocarpal and radioulnar joints. However, intraarticular distal radius fractures are difficult to treat. Reduced intraarticular fracture necessitates careful observation of the fracture pattern, cartilage injury, soft tissue condition, and carpal malalignment. Authors have attempted to use developments in 3D printing into planning for malunion distal radius fracture correction. This method has not been used in any Indonesian center. As a result, the purpose of this study is to report on the use of 3D printing in planning for the treatment of malunion distal radius fracture.

2. Method

This study is a case series study from three cases of nonunion distal radius fractures performed in Fatmawati General Hospital, Jakarta. All patients were recruited after being informed and given their consents. Medical history and physical examination were obtained directly by authors from the patients. Radiologic examinations were obtained from

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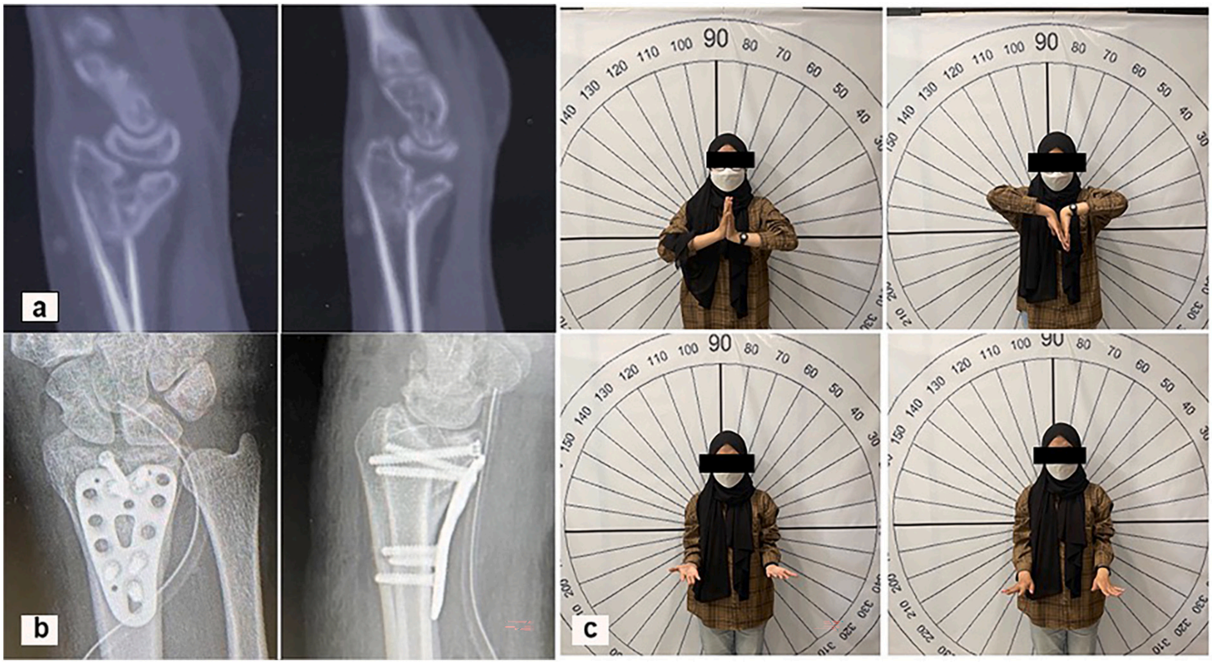

Fig. 1. (a) Preoperative CT scan demonstrating intraarticular malunion with significant gap and step, (b) post-operative X-ray demonstrating excellent reduction of intraarticular fragment, and (c) four-month post-operative follow-up.

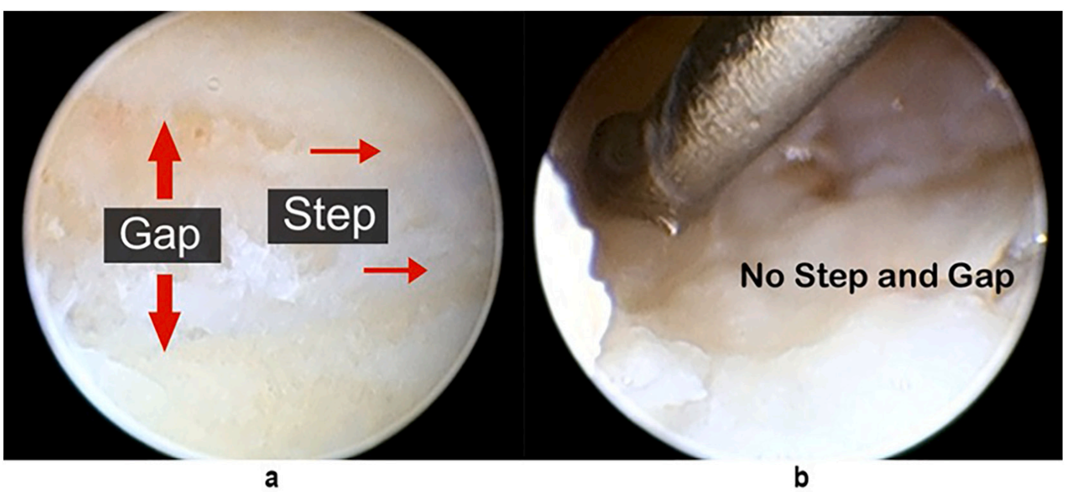

Fig. 2. The radiocarpal view of the wrist shows (a) an intraarticular gap and step, and (b) no gap and step after osteotomy and reduction.

hospital electronic medical record. All patients had undergone 3D reconstruction printing in a well-known 3D printer in South Jakarta and were being discussed by authors. Wrist arthroscopy and corrective osteotomy were performed directly by authors. This case series has been written following the PROCESS 2020 criteria [3].

3. Case illustration

3.1. Case 1

A 24-year-old lady presented with primary complaints of wrist pain nine months ago. The patient injured her wrist while cleaning her house. The patient subsequently went to see a massage therapist and had a massage, but the complaint did not go away. The physical examination of the patient revealed ROM flexion 60^0, extension 60^0, pronation 63^0, and supination 34^0. The patient was diagnosed with an intraarticular distal radius fracture with AOS OTA 23-B3 classification. Malunion reconstruction was planned using a 3D CT scan and 3D printing to help with the osteotomy line. The patient had arthroscopy-guided intra-articular osteotomy and 3D-printed extraarticular osteotomy correction. Her flexion, extension, supination, and pronation ROM improved after surgery to 76^0, 80^0, 88^0, and 87^0, respectively. Patient-Related Wrist Evaluation (PRWE) and Quick Disabilities of Arm, Shoulder, and Hand (QuickDASH) scores improved preoperatively and postoperatively. The patient's PRWE score increased from 18 to 14, and his QuickDASH score decreased from 23 to 10 (Figs. 1, 2).

3.2. Case 2

A 37-year-old man presented to the hospital with primary complaints of difficulties moving his left wrist following a car accident 12 months prior. The patient was massaged by a traditional healer. The patient

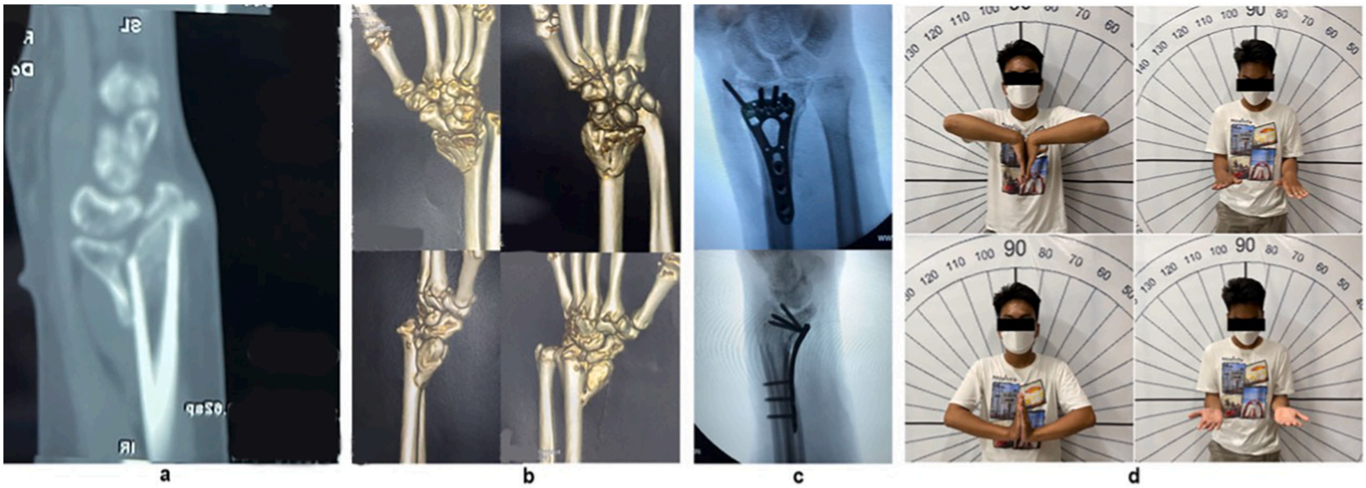

Fig. 3. (a) Pre-operative CT scan and (b) 3D reconstruction demonstrating intraarticular malunion, (c) post-operative X-ray, and (d) 5-month post-operative follow-up demonstrating good range of motion.

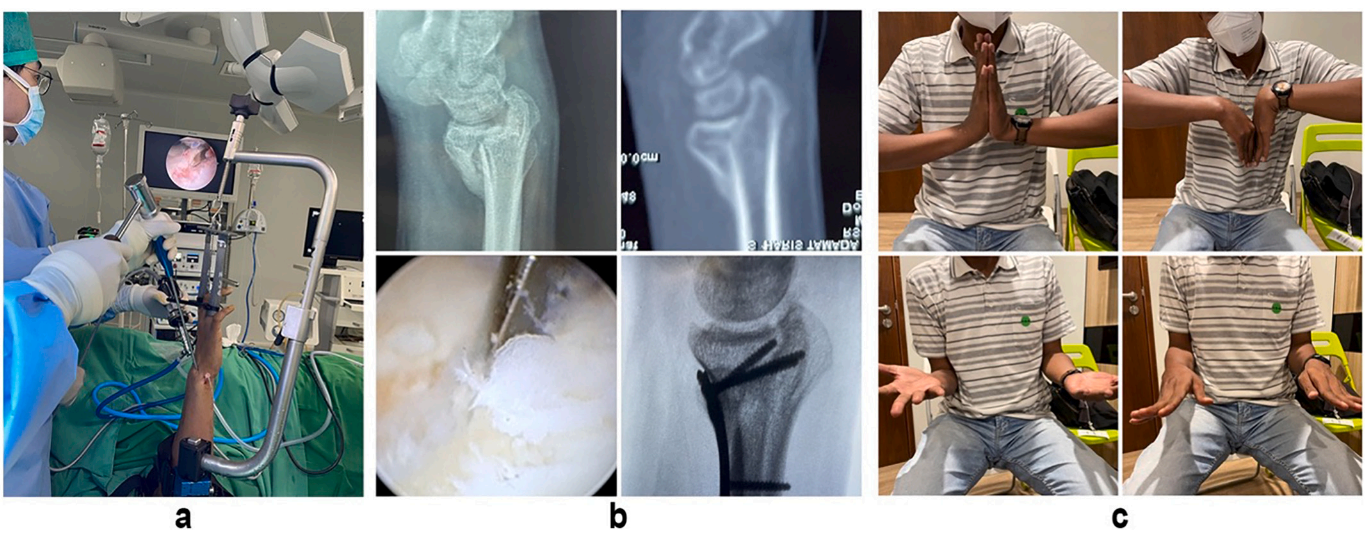

Fig. 4. (a) Wrist arthroscopy setup for arthroscopic guided intraarticular osteotomy, (b) preoperative imaging, intraarticular osteotomy view, and postoperative imaging after fixation, and (c) clinical follow-up at 5 months.

went to the hospital when his symptoms did not improve despite repeated massages. The ROM of flexion, extension, supination, and pronation were 54^0, 44^0, 45^0, and 54^0, respectively, based on physical examination. A CT scan was then used to assess the patient, and the reconstruction results were printed using a 3D printer. Corrective osteotomy was then performed on the patient using the same procedure as patient 1. The flexion, extension, supination, and pronation ROMs after surgery were 81^0, 85^0, 98^0, and 100^0, respectively. The QuickDASH and PRWE questionnaires revealed improvements from 15 to 13 and 18 to 12, respectively.

3.3. Case 3

A 32-year-old man presented with complaints of right wrist pain dating back six months. The patient had a history of car accidents in the past. Following an injury, the patient went to a massager and had the wrist area massaged. The patient's problems did not improve after numerous massages, so he was taken to the hospital. According to the physical examination, the flexion ROM was 43, the extension ROM was 53, the supination ROM was 31, and the pronation ROM was 68. Fig. 3 shows the findings of the X-ray examination, CT scan, and three-dimensional reconstruction (Fig. 4).

After corrective osteotomy was performed, there were improvements in flexion, extension, supination, and pronation ROM to 84^0, 83^0, 88^0, and 87^0, respectively. Quick DASH and PRWE questionnaire assessments showed improvement from 30 to 17 and from 17 to 13, respectively.

4. Discussion

Malunion is a common complication following the management of unstable distal radius fractures which are non-operatively or inadequately treated. Until now, there has been no clear definition for malunion of distal radius fractures, but several studies described the unacceptable healing of distal radius fractures if it has the following criteria [4,5],

1. Radial inclination <10-
2. Volar tilt >20-, dorsal tilt >20-
3. Radial height <10 mm
4. Ulnar variance >2+
5. Intra-articular step or gap >2 mm

Fig. 5. A 3D printed model of distal radius malunion is shown. The red line depicts the osteotomy plan. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

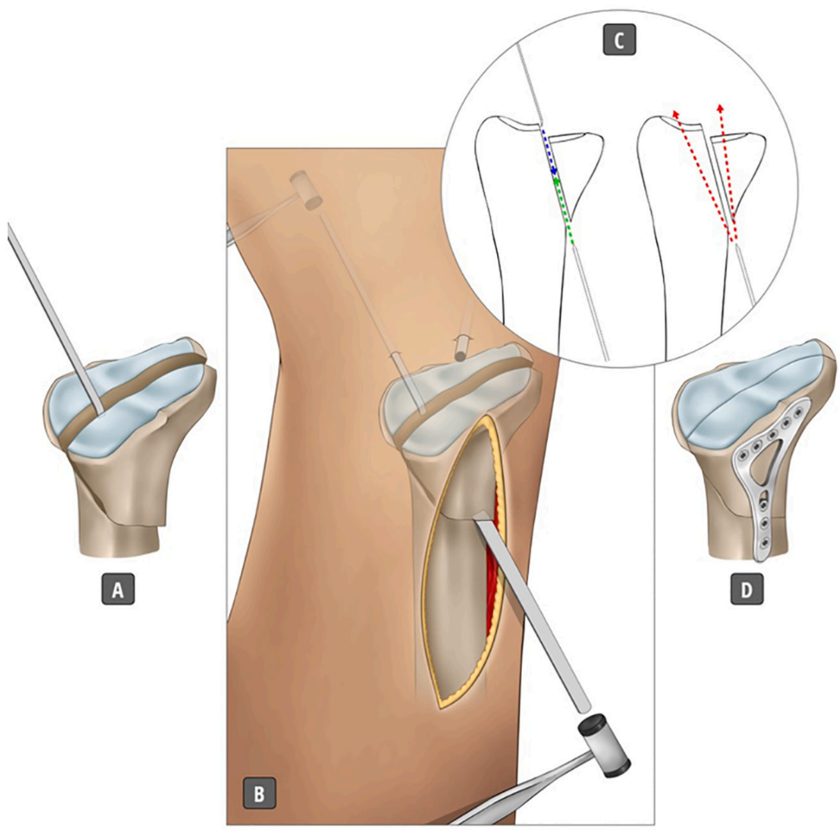

Fig. 6. The radiocarpal joint; (a) intraarticular osteotomy along the plane of malunion, (b) extraarticular osteotomy with planned ostetotomy line to ensure excellent approximation when the reduction and plate are applied, (c) demonstrating the importance of intraarticular osteotomy so that the osteotom does not exit outside the plane of malunion (into the unnafected cartilage), and (d) demonstrating reduced intraarticular fragment.

The main goals of surgery for fractures of the distal radius of the malunion are to restore radiocarpal and DRUJ congruence to restore function, reduce pain, and prevent arthritis.

The right time for surgery is as soon as possible as long as the bones are still in good condition and the wrist function is still adequate. In general, 5–8 weeks after fracture is a suitable time when it is still possible to make corrections easily and without a bone graft [6]. After 4–6 months from the onset of the fracture, correction becomes more difficult as callus remodeling has occurred [7]. In this case, all three patients had passed eight weeks after fracture, so correcting all three malunions was difficult.

Preoperative planning plays an important role because correction must be done as accurately as possible to minimize incongruence that can cause secondary arthritis [8]. Preoperative planning can be performed ranging from manually drawing surgery plans to virtual three-dimensional structures using computer. Correction of intra-articular malunion is the most crucial aspect of osteotomy performed to restore articular surface congruence. If the osteotomy is performed only from the outside (extraarticular), there is a strong likelihood that the osteotomy site will escape through the healthy portion of the joint, not the initial fracture line. The procedure is generally more complex and requires careful attention to fracture pattern, cartilage condition, soft tissue condition, presence of carpal malalignment, and wrist limitation. In this paper, all the three cases were considered to be challenging because all three were intra-articular fractures and had to be carefully planned (Figs. 5, 6).

Several institutions have used printed three-dimensional models. Available studies showed good radiographic and functional outcomes after using three-dimensional models. Chen et al. showed that planning with a three-dimensional model could reduce the frequency of fluoroscopy usage, reduce blood loss, and shorten operating time. However, the postoperative functional outcomes obtained were equal to the routine planning group [9]. Inge et al., in their case report showed that patients with a distal radius fracture malunion showed normal ROM outcomes within three months postoperatively. In addition, Inge et al. also showed that three-dimensional printing can be done at an affordable cost [10]. In these 3 cases, we used the affordable printing resin material. Bizzotto et al. also showed that the creation of a three-dimensional model could also be applied to provide education to patients so that patients know the surgical action plan that will be carried out, which leads to increased patient compliance [11].

5. Conclusion

Utilizing a three-dimensional model during surgery planning and intraarterial guided osteotomy are crucial variables that aid in the successful treatment of malunion distal radius fractures. However, few studies have compared the results of utilizing three-dimensional models with those of conventional methods, thus it cannot be determined whether the use of three-dimensional models is superior to conventional approaches.

Provenance and peer review

Not commissioned, externally peer-reviewed.

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This case report did not intervene with patients' treatment plans and hence did not require ethical approval.

Ethical approval

Ethical approval was not required in the treatment of the patient in this report.

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.

Registration of research studies

Not applicable.

Guarantor

Oryza Satria.

CRediT authorship contribution statement

Oryza Satria: Conceptualization, Methodology, Validation, Investigation, Supervision, Project administration. **Irsan Abubakar:** Conceptualization, Methodology, Validation, Investigation. **Syahdi Farqani:** Methodology, Investigation, Resources, Writing – review & editing. **Irfan Kurnia Pratama:** Methodology, Validation, Investigation, Writing – original draft, Writing – review & editing, Visualization.

Declaration of competing interest

The authors declare no conflicts of interest.

References

[1] S. Delclaux, T.T. Trang Pham, N. Bonnevialle, C. Aprédoaei, M. Rongières, P. Bonnevialle, et al., Distal radius fracture malunion: importance of managing injuries of the distal radio-ulnar joint, Orthop. Traumatol. Surg. Res. 102 (3) (2016 May) 327–332.

[2] A.J. Bronstein, T.E. Trumble, A.F. Tencer, The effects of distal radius fracture malalignment on forearm rotation: a cadaveric study, J. Hand Surg. 22 (2) (1997 Mar) 258–262.

[3] R.A. Agha, C. Sohrabi, G. Mathew, T. Franchi, A. Kerwan, N. O'Neill, et al., The PROCESS 2020 guideline: updating consensus preferred reporting of CasESeries in surgery (PROCESS) guidelines, Int. J. Surg. 84 (2020 Dec) 231–235.

[4] S.C. Haase, K.C. Chung, Management of malunions of the distal radius, Hand Clin. 28 (2) (2012 May) 207–216.

[5] J.M. Cognet, O. Mares, Distal radius malunion in adults, Orthop. Traumatol. Surg. Res. 107 (1) (2021 Feb), 102755.

[6] T.D. Luo, F.A. Nunez, E.A. Newman, F.A. Nunez, Early correction of distal radius partial articular malunion leads to good long-term functional recovery at mean follow-up of 4 years, Hand (N. Y.) 15 (2) (2020 Mar) 276–280.

[7] B.T. Evans, J.B. Jupiter, Best approaches in distal radius fracture malunions, Curr. Rev. Musculoskelet. Med. 12 (2) (2019 Jun) 198–203.

[8] M.K. Hsieh, A.C.Y. Chen, C.Y. Cheng, Y.C. Chou, Y.S. Chan, K.Y. Hsu, Repositioning osteotomy for intra-articular malunion of distal radius with radiocarpal and/or distal radioulnar joint subluxation, J. Trauma Injury Infect. Crit. Care 69 (2) (2010 Aug) 418–422.

[9] Y. Chen, X. Liang, S. Zheng, Y. Wang, W. Lu, Association of body fat mass and fat distribution with the incidence of hypertension in a population-based Chinese cohort: A 22-year follow-up, Mar 20 [cited 2020 Aug 15], J Am Heart Assoc [Internet] 7 (6) (2018), https://doi.org/10.1161/JAHA.117.007153. Available from.

[10] S. Inge, L. Brouwers, F. van der Heijden, M. Bemelman, 3D printing for corrective osteotomy of malunited distal radius fractures: a low-cost workflow, BMJ Case Rep. (2018). Jul 24;bcr-2017-223996.

[11] N. Bizzotto, I. Tami, A. Tami, A. Spiegel, D. Romani, M. Corain, et al., 3D printed models of distal radius fractures, Injury 47 (4) (2016 Apr) 976–978.