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Comparison of blind surgical zone in the Henry vs. Kocher approach in the treatment of partial radial head fractures

Yunfei Li, PhD *, Huizhang Li, PhD, Yongjian Lu, PhD, Jiahui Jiang, PhD

Department of Orthopedics, Jiading District Central Hospital Affiliated Shanghai University of Medicine & Health Sciences, Shanghai, China

A R T I C L E I N F O

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Background: The Kocher approach is often adopted for surgical treatment of partial radial head fractures. However, anterior exposure of the radial head is limited by the Kocher approach. Radial head fractures are predisposed to be located at the anterior radius. The deviation of susceptible fracture locations against the regular operative approach imposes certain challenges on surgical procedures. This study explored whether there are any clinically significant differences in the exposure between the Henry and Kocher approaches.
Materials and methods: Ten fresh-frozen cadaveric upper limbs were obtained as specimens. The radial head was exposed by both the Henry and Kocher approaches, followed by a long-axis parallel incision at the joint capsule until the capsular attachment was reached; the extracapsular ligaments and surrounding soft tissues were avoided. The 2 approaches were compared in the blind zone and in the visualized area.
Results: The blind-zone arc of radial head exposure with the Henry and Kocher approaches averaged $132^\circ \pm 16^\circ$ and $112^\circ \pm 21^\circ$, respectively. The supinated angle between the borderline of the blind-zone arc and the biceps tuberosity–radial medullary cavity centerline averaged $268^\circ \pm 20^\circ$ and $75^\circ \pm 16^\circ$, respectively.
Conclusions: The Henry approach offered optimal exposure of the anterior and lateral radial head but had a blind zone at the posteromedial radial head, whereas the Kocher approach offered optimal exposure of the posterolateral radial head but had a blind zone at the anterolateral radial head. The Henry approach could be a better option for specific management of radial head fractures based on the fracture location.

Clinically, the Kocher approach is commonly used for surgical treatment of partial radial head fractures.[4] It has the advantage of easy proximal and distal extension. For partial radial head fractures, the anterolateral quadrant of the radial head is most commonly involved[14]; the Kocher approach often inadequately exposes the anterior fracture.[9] The deviation between fracture locations and the operative approach imposes a great challenge on the operation. Surgeons can extend the incision, which will inevitably lead to increased trauma. Some research has suggested modified lateral approaches, such as the extensor digitorum communis split approach or Kaplan approach, by which the exposure was improved, but the issue was not completely resolved.[3] This study explored whether there are any clinically significant differences in the surgical exposure of the radial head sites by the Henry vs. Kocher approach and examined how to more accurately expose the fracture locations, thereby improving fracture management.

Materials and methods

Ten fresh-frozen cadaveric upper-limb specimens were provided by the Shanghai Medical College of Fudan University. Those with local deformities or surgical scars were excluded. All specimens underwent surgery by the same surgeon. The 2 most classic approaches for exposing the radial head were used in all specimens. These 2 approaches preserved various nerve planes and accommodated the complete intermuscular space, without any breakage or osteotomy at the starting point of the muscle. These approaches were chosen because they demand no special postoperative protection and meet the requirements of early functional exercise.

The first approach used was the conventional posterolateral Kocher approach (without osteotomy or proximal-end expansion). With the forearm positioned in pronation and the elbow positioned in flexion, an incision was made between the anconeus and

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* Corresponding author: Yunfei Li, PhD, Department of Orthopedics, Shanghai Health Medical College, Jiading District Central Hospital, Shanghai 201800, China.
E-mail address: jd_liyf@sumhs.edu.cn (Y. Li).

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extensor carpi ulnaris, followed by an incision of the annular ligament to expose the segment from the capitulum to the radial neck. Self-retaining retractors were used, and an examination was conducted with the forearm extremely pronated or supinated to identify the visualized area of the radial head using the Kocher approach; the radial head edge was marked with a needle to label the margin of the maximum visualized area within the incision.

The second approach used was the anterolateral Henry approach with the elbow positioned in extension and the forearm positioned in supination. An incision was made between the brachialis and brachioradialis, followed by ligation of the first brachioradialis branch of the brachial artery. The radial nerve was retracted outward before incision of the joint capsule and annular ligament to expose the capitulum humeri and radial head and neck at the interior edge of the supinator. Self-retaining retractors were then used for exposure, and an examination was conducted with the forearm extremely pronated or supinated to identify the visualized area of the radial head using the Henry approach. The anterior and posterior margins of the visualized area of the radial head were marked by the same method described earlier.

The unified standards for the approach to expose the fracture sites were as follows: The distal exposure should be up to the distal capsular attachment point, whereas the proximal exposure should be up to the upper capsule insertion point. The joint capsule was incised longitudinally, without excision or a T-shaped incision. The elbow was placed in the extension position when the Henry approach was used, whereas the elbow was flexed in the 90° position when the Kocher approach was used. These are the same limb positions as when the 2 approaches are used in clinical operations.

The visualized area was marked after incision and exposure of the radial head to pull open the site with self-retaining retractors until the capsule was exposed. Thereafter, the forearm was pronated until the maximum pronation and supination endpoints were reached, and the 2 points were labeled with needles placed vertically as far as possible on the radial head. In the posterolateral Kocher approach, the supination marker was considered the most anterior edge whereas the pronation marker was considered the most posterior edge. In the anterolateral Henry approach, the supination marker was considered the most posterior edge whereas the pronation marker was considered the most anterior edge. The implanted marker was then broken near the bone surface, with the tail end slightly above the articular surface, that is, less than 2 mm in height, without interfering with the rotation of the upper radioulnar joint. The implant depth of the marker was more than 10 mm. The sizes of the markers for the 2 operative approaches differed, thereby ensuring easy distinction of the marked approaches by visualization or computed tomography (CT) scanning.

After marking of the 2 operative approaches, CT inspection of the specimens was conducted using a Philips 64-row CT scanner (Philips, Amsterdam, The Netherlands). The results were analyzed with Boholo Surgical Simulator Software (Boholo Medical Science & Technology, Shanghai, China), and measurements in the radial head plane and radial tuberosity plane were made in 3-dimensional mode.

Radial head plane

In the radial head axial plane, the implanting points of the labeling needles in the 2 approaches were identified at the edge of the capitulum radii, and straight lines were delineated by connecting the individual implanted points with the center of the radial head. The visualized area and the blind zone in each approach were then measured and documented (Fig. 1).

Radial tuberosity plane

The peak of the radial tuberosity region was identified. On the basis of the axial plane of the location, the peak of the radial tuberosity and the center of the radial medullary cavity were identified, and a straight line connecting these 2 points was drawn.

The angle between the radial tuberosity peak—radial medullary cavity centerline and the blind borderline was measured. Because these 2 lines were in different planes, both were presented vertical to the radial long axis and were then horizontally moved to enable angle measurement (Fig. 2). The angle measurement in both approaches significantly reflected the visualized area and was then used to determine the exact location of the blind zone on the radial head (Fig. 3).

Statistical analysis

Measurements were performed by 2 separate observers (Y.L. and H.L.). The measurements were performed 3 times, and the average was determined. The intraclass correlation coefficient was calculated to assess reliability. The paired t test was performed to evaluate the differences between the range and location of the blind zone in the 2 approaches. All statistical analyses were performed using SPSS software (version 20.0; IBM, Armonk, NY, USA). The level of significance was set at an α level of .05 with 95% confidence intervals.

Results

The measurements are listed in Table I. Interobserver reliability was very high, with an intraclass correlation coefficient of 0.96. We found that with both the Henry and Kocher approaches, about one-third of the surface of the radial head was not directly visible (without an extended incision). The blind zone in the Henry approach was slightly larger than that in the Kocher approach; the cause may have been that the thickness of the soft tissue in the anterior approach was greater than that in the posterior approach. The most important finding was the location of the 2 blind zones. According to the position of the radial tuberosity, one blind zone looked like the other blind zone rotated 193°, which was close to being a mirrored position (180° rotation) on the surface of the radial head. This finding shows that the invisible area with one approach can be directly visualized with the other approach.

Figure 1 Implanted visualized-area markers for Kocher approach (*white arrows*) and Henry approach (*black arrows*) in axial plane on computed tomography scan.

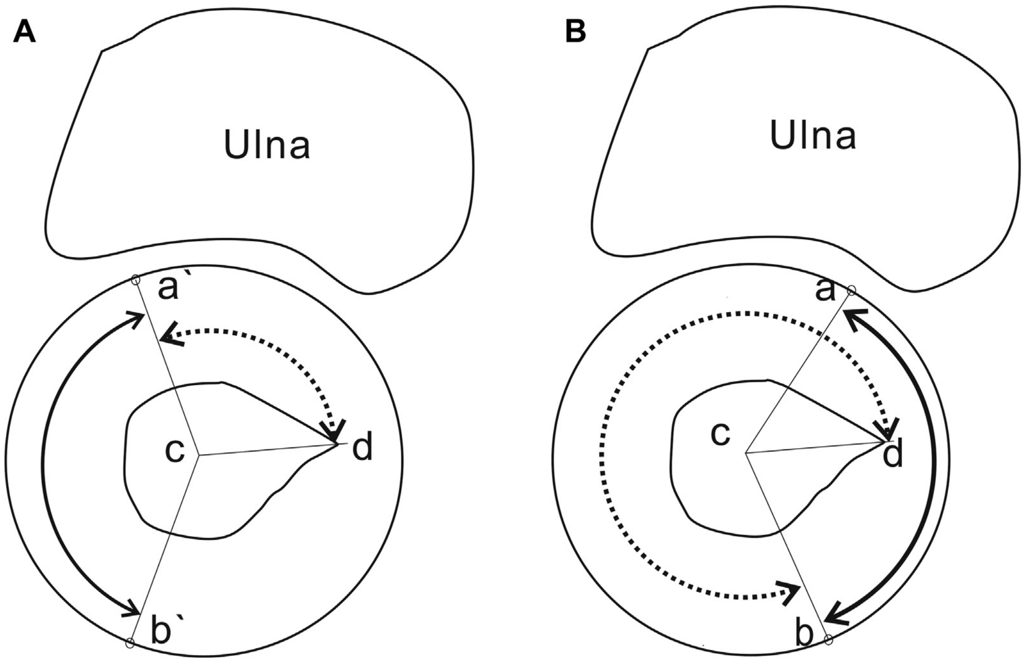

Figure 2 Illustrations of blind-zone measurement method for Kocher approach (**A**) and Henry approach (**B**). The ⟷ indicates the blind zone, and the ⇠- - - -⇢ indicates the angle between the tuberosity centerline and the blind borderline (supination orientation). *a*, *b*, *a*`, *b*`, marker points; *c*, radial medullary cavity center (overlapping radial head center); *d*, radial tuberosity.

To fully reflect these variations, we marked the illustrations with all the data (Figs. 4 and 5), and we saw that all the data add them together appear nearly 180° of blind zone. In fact, it was not so large for each individual. We used a gradient-filling integration interval to describe the possible range. The center of the blind area was not visible, the surrounding area based on soft tissue may not have been visible, and the color intensity did not reflect the accurate frequency. Gradient filling was used to facilitate understanding and visualization.

Figure 4 shows a diagram of the blind zone and chart of radial head exposure using the Henry approach. Figure 5 shows a diagram of the blind zone and chart of radial head exposure using the Kocher approach.

The blind zones of the 2 approaches looked complementary. Despite some overlap in the edges of the 2 blind zones, the locations of their centers were on opposite sides of the radial head, indicating that the optimal exposure was different in the 2 approaches. This discovery showed an area that was not visible with one approach but was directly facing the front with the other approach.

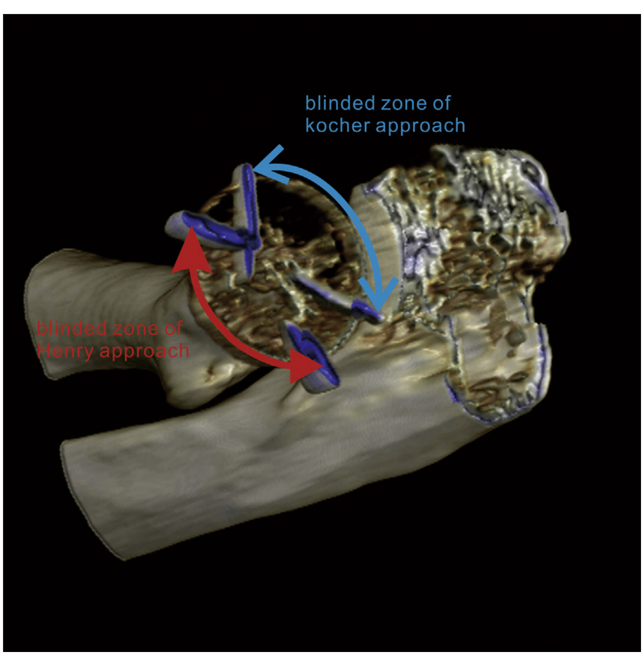

Figure 3 Image processing. The markers indicate the visualized area and the blind zone, and their locations on the radial head are illustrated by the spatial relation with the radial tuberosity for the Kocher approach (⟷) and Henry approach (⟷).

Discussion

Partial radial head fractures are the most common fractures of the elbow joint, and management remains highly controversial. As displaced fractures affect the stability and involution of the upper radioulnar joint, anatomic reduction and stabilization by internal fixation are the main principles for managing intra-articular fractures.[7,12] Proper operative exposure is essential to realize this goal, and satisfactory outcomes cannot be achieved without proper exposure or a proper operating space.[10,12] With the increased

Table I
Blind-zone size and location

	Blind-zone size	Angle between tuberosity centerline and blind borderline (supination orientation)
Henry approach,°	132 ± 16	268 ± 20
Kocher approach,°	112 ± 21	75 ± 16
t	5.122	28.103
P value	.001	<.001

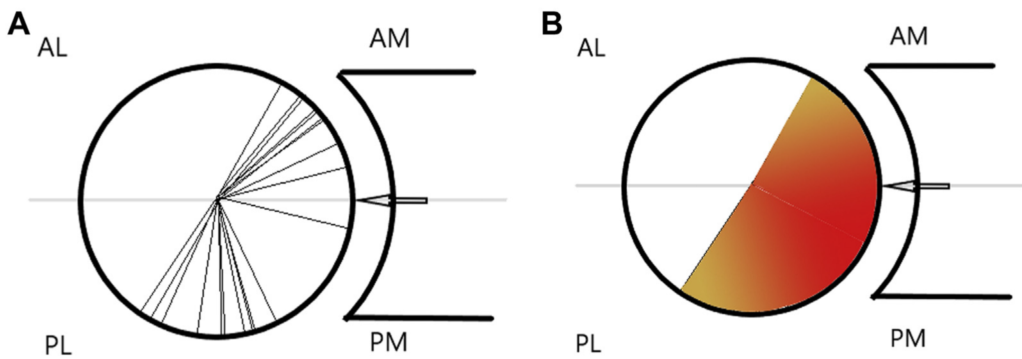

Figure 4 Distribution diagram (**A**) and distribution tendency chart (**B**) of radial head blind-zone measurements with Henry approach. The ← indicate the location of the radial tuberosity. *AL*, anterolateral; *AM*, anteromedial; *PL*, posterolateral; *PM*, posteromedial.

application of CT inspection, more comminuted radial head fractures have been identified, and repair of these mostly rely on proper exposure of all fracture lines. For partial fractures, internal fixation with screws remains the mainstream treatment, which has shown better therapeutic effects.[1,5,15,16] When a plate is applied, it must be placed in the safety zone, whereas there is no such concern when using a headless screw. Application of headless screws assists in choosing the operative approach.

A study conducted by van Leeuwen et al[14] demonstrated that partial radial fractures mostly occur in the anterior location, and the same result was reported by Guitton et al[8] and Mellema et al.[11] However, the Kocher approach has an obvious blind zone in the exposure of the anterior radial head; a challenge occurs with exposure when operatively treating partial radial fractures.

This study revealed differences in exposure between the Henry and Kocher approaches. As reported by van Leeuwen et al,[14] the exposure in the Henry approach showed better overlapping with the susceptible location of radial fractures, indicating proper exposure and a proper operating space for partial radial head fractures. Moreover, the screw positions could be more flexibly chosen, thereby achieving better biomechanical effects.[13]

Some researchers have revised the current operative approaches for the radial head. In the conventional Kocher approach, an incision is made at the entry between the anconeus and extensor carpi ulnaris. Barnes et al[2] revised the incision to be between the extensor carpi radialis and extensor digitorum to enable appropriate forward movement and to slightly improve the exposure anteriorly. Desloges et al[6] suggested the extensor digitorum communis split approach, the idea of which is similar to the Kaplan approach. However, the extensor carpi radialis and extensor digitorum both originate from the lateral epicondyle, and the shared origin limits the space of stretching forward. Surgeons often need to extend the approach to gain more frontal exposure, such as detachment of the origin of these muscles and capsules for screw placement.[3] With the more direct frontal exposure, there is no need to cut off any muscles, which is the most distinguishing feature between the Henry approach and these modified lateral approaches. The focus of our research is not to compare these modified lateral approaches. Besides, many researchers have explored various revisions of the lateral approach, implying that the current lateral approach (including the posterolateral approach) has critical drawbacks in managing partial radial head fractures.[2,3,6,9]

Hence, a classification of partial radial head fractures is suggested, as follows: In the radial head plane, a virtual line is drawn with a 45° supinated angle between this line and the radial tuberosity centerline. The radial head surface is divided into 2 regions, and fractures located in the anterolateral region are deemed the anterolateral type whereas those in the opposite location are deemed the posteromedial type (Fig. 6). Fractures that cannot be classified as either of these types are considered hybrid-type fractures. Posteromedial fractures can be managed by the Kocher approach, whereas anterolateral fractures can be managed by the Henry approach. The hybrid type can be managed by either the Kocher or Henry approach or a combined approach. According to our study, when the forearm is in the supinated position, the blind zone with the Henry approach is in the posteromedial aspect and the anterolateral surface is well exposed. In contrast, with the Kocher approach, the blind zone is in the anterolateral aspect and the posteromedial side is well exposed. With this classification

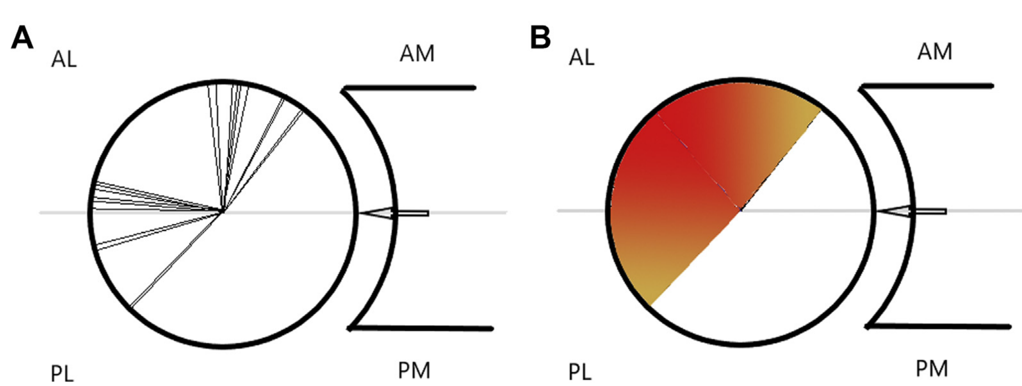

Figure 5 Distribution diagram (**A**) and distribution tendency chart (**B**) of radial head blind-zone measurements with Kocher approach. The ← indicate the location of the radial tuberosity. *AL*, anterolateral; *AM*, anteromedial; *PL*, posterolateral; *PM*, posteromedial.

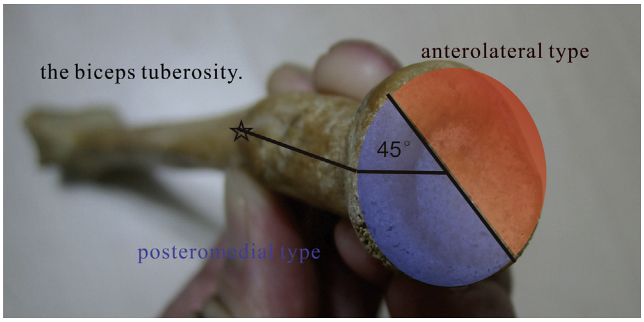

Figure 6 New classification of partial radial head fractures based on computed tomography scan. The ☆ is the peak of the radial tuberosity.

system, surgeons may make full use of the difference between the 2 different approaches to achieve good fracture exposure, minimize the incision, protect the soft tissue, and achieve better recovery.

However, our study has the limitation of including an inadequate number of specimens, which might incompletely cover the variations in the blind zone.

Conclusion

This study demonstrated the differences in the blind zone between the Henry and Kocher approaches. We obtained good visualization of both the anterior and lateral parts of the radial head by the Henry approach, with the blind-zone location being posterior and medial, whereas the opposite occurred with the Kocher approach. Good visualization controls the quality of fracture reduction and fixation. This study suggests that the Kocher approach is not suitable for all partial radial head fractures and, moreover, that the anterior part is more crucial in such fractures. We recommend obtaining CT scans of fractures preoperatively and distinguishing partial radial head fractures into 3 types: anterolateral, posteromedial, and hybrid. The surgeon can choose the suitable approach based on the classification. The Henry approach could be a better option for specific management of partial radial head fractures.

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