CHANGE OF CARPAL ALIGNMENT UNDER ANAESTHESIA: ROLE OF PHYSIOLOGICAL AXIAL LOADING ON CARPUS

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Abstract
Patients with distal radial fracture undergoing general anaesthesia for management of their injury were employed for the present study. The contralateral normal wrist was assessed for any change in the carpal alignment under anaesthesia due to the eliminated physiological axial load. Lateral radiographs of the uninjured wrist joint were performed in twenty patients with distal radial fracture. Radiographs were taken before and after giving general anaesthesia along with the muscle relaxants and were repeated after applying the traction in line with the long axis of the radius. Radiographs taken under anaesthesia showed scaphoid and lunate to adapt position of relative extension with decrease in radioscaphoid, radiolunate and scapholunate angles. A further decrease in all three angles was seen in the traction radiographs. Lunate is described to have tendency to extend due to its shape which is thinner dorsally. Our observations however, demonstrated lunate to tend to flex in an intact carpus under the effect of the flexion torque from the scaphoid. The capitate’s compressive force becomes effective and is able to extend lunate only when there is discontinuity in SLIL not allowing lunate to avail flexion torque from the scaphoid. Our results also failed to support the view that scapholunate intersosseous ligament is in continuous tension due to the tendency of the scaphoid and lunate to move in the opposite directions.

Key Words
Carpals under anaesthesia, Lunate, Axial Load, Carpal Alignment, Traction Radiograph, Radiolunate angle

1. Introduction
Carpal alignment refers to the measurement of relationship of different carpal bones with each other and with the distal radius. It not only has great diagnostic significance in evaluating integrity of various ligaments of the wrist but has prognostic value as well. The proximal carpal row has no muscles attached to it and alignment of this intercalated segment is dictated through ligaments, the shape of the joint surfaces of the neighboring bones and by the axial load working across the joint due to the tone of the forearm muscles. Axial load has been described to produce flexion, radial deviation and supination of the proximal carpal row. It is also reported to maintain the proximal carpal row in a state of stable equilibrium. The role of the axial compression is further emphasized through reports where cadaveric studies to experimentally produce various carpal malalignment or instability patterns by sequential cutting of the various ligaments failed in their objectives unless the experiment was combined with an axial compressive load.

There are reports describing effect of the axial compression over the carpals and the distraction as well. However, an effort to eliminate the physiological axial compression and study its effect over the carpal alignment has not been described. The present work aimed to make an in-vivo study to deprive carpals of the normal physiological axial load due to the muscle tone and to assess its effect on various carpal alignments. Uninjured arm of those patients who required general anaesthesia with complete muscle relaxation for the management of their injury provided experimental material for the said objective.

2. Methods
The present study comprised of twenty patients with unilateral distal radial fractures undergoing various treatment procedures. There were fourteen men and six women with mean age of 31.1 years (SD 7.79). The contra lateral uninjured wrist of all the patients was radiographed in both PA and lateral view after obtaining a written consent. The patients were included in the study only after ruling out any anatomical abnormality. The lateral radiographs were taken again in the operating room under balanced endotracheal anaesthesia with full skeletal relaxation by administering non – depolarizing muscle relaxant. Radiographs were obtained before and after application of the traction by suspending wrist from finger traps applied to thumb, index and middle finger for three minutes in line with the long axis of the radius by 5 kg weights. An assistant maintained the neutral position of the wrist particularly in relationship to radial and ulnar deviation by holding forearm and fingers. An image intensifier was used to ensure strict lateral view before exposing the film.
A set of three lateral radiographs was obtained for each subject i.e. radiograph without anaesthesia, with anaesthesia and with traction under anaesthesia. The radiolunate (RLA), radioscaphoid (RSA) and scapholunate angles (SLA) were measured on all the three lateral views and changes in their values between different radiographs were determined separately for each set. The lunate axis was drawn as a line perpendicular to the line tangential to the poles of the lunate while the scaphoid axis was the line tangential to the palmar outlines of the proximal and distal poles. The line through the center of the medullary canal at 2 and 5 cms proximal to the radiocarpal joint formed the axis of the radius.\(^\text{12}\). SLA was drawn as angle between axes of scaphoid and lunate, while RLA and RSA were measured as angles between axis of radius and that of lunate and scaphoid, respectively (Fig. 1). The observer was blinded to the group of the radiographs. Intraobserver variability was assessed by redrawing of all lines on completely cleaned radiographs, showing no traces of the previously used lines and measuring various carpal angles again by the same author at an interval of three months. The observer variability was analyzed using Pearson’s coefficient of correlation. Paired samples \(t\) test was used to determine between-groups differences of each carpal angle. The level of significance was set at \(p < .05\). All statistical analyses were performed using SPSS for Window (Version 9.0, SPSS Inc., Chicago, IL).

3. Results

Radiographs of all the patients were divided into three groups namely, normal view (group I), view under anaesthesia (group II) and the traction view (group III). Measurements of various angles are illustrated in Table –1. The capitae’s compressive force provides the lunate a tendency to dorsiflex due to its shape of a wedge with the apex dorsally, while the scaphoid flexes under the constraint and the proximal force from the trapezium and trapezoid\(^\text{13}\). Logic suggests that the reduction of the axial load, as would occur in a paralyzed subject should “unwind”, thereby relaxing, the SLIL causing the scaphoid to dorsiflex and the lunate to flex with a resultant decrease in SLA. The present study, however, failed to confirm this demonstrating no change in the SLA. On the contrary, the radiographs under anaesthesia (group II) demonstrated lunate to have rotated to dorsiflexion with decrease in the RLA (\(p = .019\)) and RSA also in comparison to radiograph taken without anaesthesia (Fig. 2).

Table – 1

<table>
<thead>
<tr>
<th>Group</th>
<th>SLA (Mean (SD))</th>
<th>RSA (Mean (SD))</th>
<th>RLA (Mean (SD))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Normal view</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Initial)</td>
<td>48.60 (11.09)</td>
<td>55.80 (9.93)</td>
<td>7.20 (8.97)</td>
</tr>
<tr>
<td>Repeat</td>
<td>48.50 (11.79)</td>
<td>55.50 (9.70)</td>
<td>6.95 (8.40)</td>
</tr>
<tr>
<td>2. Anaesthesia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>view (Initial)</td>
<td>46.10 (9.54)</td>
<td>46.80 (7.92)</td>
<td>0.75 (6.03)</td>
</tr>
<tr>
<td>Repeat</td>
<td>45.60 (9.52)</td>
<td>46.05 (8.49)</td>
<td>0.70 (6.06)</td>
</tr>
<tr>
<td>3. Traction view</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Initial)</td>
<td>33.40 (8.35)</td>
<td>32.30 (8.78)</td>
<td>-1.10 (6.21)</td>
</tr>
<tr>
<td>Repeat</td>
<td>32.50 (9.37)</td>
<td>31.45 (8.99)</td>
<td>-1.05 (6.68)</td>
</tr>
</tbody>
</table>

* negative angle depicts dorsiflexed lunate

Table – 2

<table>
<thead>
<tr>
<th></th>
<th>SLA ((p – \text{Values}))</th>
<th>RSA ((p – \text{Values}))</th>
<th>RLA ((p – \text{Values}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gr. I vs Gr. II</td>
<td>Not significant</td>
<td>.005</td>
<td>.019</td>
</tr>
<tr>
<td>Gr. I vs Gr. III</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>.002</td>
</tr>
<tr>
<td>Gr. II vs Gr. III</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>Not significant</td>
</tr>
</tbody>
</table>

Diagrammatical representation showing measurement of the various carpal angles. Please note decrease/increase of measured RSA and RLA would mean dorsal/volar rotation of the scaphoid and lunate bones, respectively with respect to the radius. The two bones moving away from each other by flexion of the scaphoid and dorsiflexion of the lunate produce increase in SLA while movement of either bone in the opposite directions produce decrease in SLA.
Lateral radiographs of the wrist (a) before anaesthetizing the patient, (b) radiograph after the anaesthesia showing marked dorsiflexion of the lunate from its volarly rotated alignment in figure 1 a, (c) radiograph after application of the traction. Note the distracted midcarpal joint along with the dorsiflexed scaphoid and also the decrease in RSA and RLA.

No significant change was found to occur in SLA between groups I and II. The lateral views on traction radiographs (group III) showed statistically significant decrease in all the carpal angles from both the previous groups of radiographs except the RLA which showed significant decrease from the group I only (Table - 2). The intraobserver variability was 0.40 (S.D. 2.29). The correlation of intraobserver variability was 0.995 ($p < .001$).

4. Conclusion

The axial compression is classically described to dorsiflex the lunate due to its dorsally thinned wedge shape$^{13}$ but one out of every three persons is reported to have a lunate with either the thinner volar segment or an equal dorsal and volar segment $^{14}$. Even the classical wedge shape of the lunate with thinner dorsal segment does not necessarily favor a tendency to dorsiflex unless the axis of the capitate compressive force is well posterior to the centre of rotation of the lunate or posterior to the point of counter force from the distal radial articular surface (Fig. 3a). Possibility of these forces tending to dorsiflex the lunate is further reduced due to the flexed attitude of the lunate (Fig. 3b) in the majority of wrists joints $^{15}$. It is therefore not surprising that there was no correlation between the lunate’s shape and the RLA$^{14}$. Contrary to the classical description, the present study has demonstrated physiological axial loading due to the normal tone of the forearm muscles to flex the scaphoid and the lunate.

The classical lunate with thinner dorsal segment. (a) the axial load can rotate the lunate to extension only if it forms a force couple with a parallel and equal force working at a distance anterioely and in opposite direction. The latter force is provided by the counteracting distal radial surface against the articulating lunate. (b) - the capitate compressive force not always maintains an alignment posterior to its counter force from the radius. This becomes still more difficult with even slight flexion of the lunate with its dorsal translation.
Our study doesn’t support the view that scapholunate interosseous ligament is in continuous tension due to the tendency of the scaphoid and lunate to move in the opposite directions. We believe lunate to be in a position of forced flexion, due to the scaphoid flexion torque under the axial compressive load from trapezium and trapezoid. It is suggested that the capitatively compressive force is in a position to dorsiflex the lunate, only when the lunate is separated from the palmarex flexing influence of the scaphoid following breach in continuity between the scaphoid and the lunate.

5. References