

# Morphometry of distal end radius in the Indian population: A radiological study

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## ABSTRACT

**Introduction:** The morphometry of distal end radius (DER) comprises the four necessary parameters: radial inclination, palmer tilt, radial height, and ulnar variance. The unblemished intellect about the morphometry is urged for the management of fracture of DER. The goal of our study was to determine the values of morphometric parameters of the DER from the adult Indian.

**Materials and Methods:** It was a single hospital- based observational cross-sectional, prospective study. Radial inclination, radial height, and ulnar variance were measured on posteroanterior view, and the measurement of palmer tilt was accomplished on the lateral view. All the statistical analysis was done by Microsoft XL 2007 (data add in function were installed for data analysis). T-test was used for comparing the means of the parameters.

**Results:** Two hundred and forty two ( $n = 242$ ) X-rays were included in this study to analyze. The mean value ( $n = 242$ ) of radial inclination was  $23.27^\circ \pm$  (standard deviation [SD])  $7.42^\circ$  (range:  $11.3-42.1^\circ$ ), palmer tilt  $10.07^\circ \pm$  (SD)  $5.28^\circ$  (range:  $1-16.9^\circ$ ), radial height  $11.31 \text{ mm} \pm$  (SD)  $4.9 \text{ mm}$  (range:  $7.1-30.4 \text{ mm}$ ), and ulnar variance  $0.66 \text{ mm} \pm$  (SD)  $2.46 \text{ mm}$  (range:  $-2.4$  to  $+4.1$ ).

**Conclusion:** This study may provide an inaugurator plinth to prosecute the further analytical research in the Indian population. Moreover, the data may also be used as a reference data for the anatomical alignment while treating the injuries of the DER in the Indian population.

**Key words:** Distal end radius, morphometry, parameters

**MeSH terms:** Radius, morphology, wrist joint, radiography

## INTRODUCTION

The merit of fracture reduction of distal end radius (DER) is saliently evaluated by the restoration of the prefractured value of radial inclination and the volar tilt.<sup>1</sup> Loss of the radial height along with the altered palmer tilt has the substantial influence in the kinesiology and the grip strength of wrist joint.<sup>2,3</sup> Furthermore, the ulnar variance is important parameters for the management of

the DER.<sup>4</sup> Hence, the morphometric measurement of the DER includes the necessary parameters as radial inclination, palmer tilt radial height, and ulnar variance. Morphometry of the DER is significant in various conditions such as fracture of distal radius, distal radius plate design, and kinesiology.

Amidst the chronicle of the management of the DER, there has been a central issue of the relationship between the anatomical and the functional result.<sup>5</sup> There are very fewer studies available for the morphometry of distal radius in the Indian population.<sup>6,7</sup> Hence, the unblemished intellect about the morphometry is urged for the management of DER. The goal of our study was to determine the values of radiographic morphometric parameters of the DER among the adult Indian.

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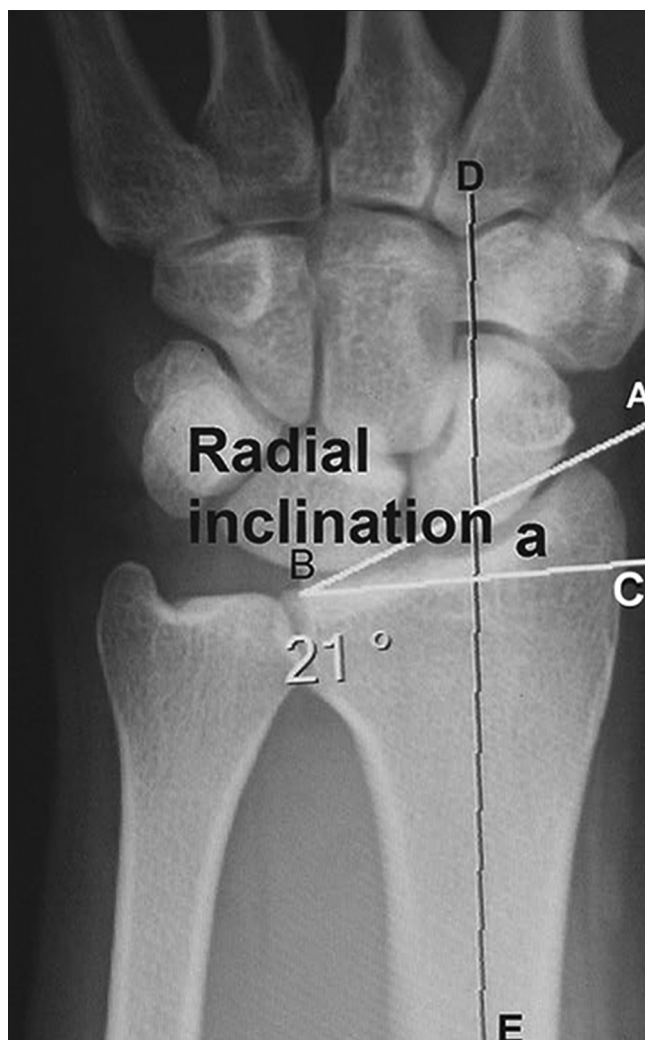
## MATERIALS AND METHODS

It was a single hospital based, observational cross sectional, prospective study, which was carried out (May 2014 to October 2014) at the one transcendent hospital of India. Successive wrist radiographs (either right or left) of the patients were taken in the hospital, who visited with the wrist-related complaints. For the morphometry of the DER, we included the radial inclination, palmer tilt, radial height, and ulnar variance as parameters.

We included the wrists only with the fused epiphysis. We excluded the entire wrist X-rays of the unossified bone and showing the irregularities due to structural deformity, injured DER, and pathological conditions (i.e., arthritis) because they could have been responsible for the mismeasurement. We also compared the right and left side's morphometric values of patients.

The standard protocol was followed for taking the wrist radiographs. Only the true posteroanterior (PA) and lateral X-rays (with neutral rotation) were considered in the study and the films, not centered over the wrist and with the rotation were discarded. For keeping the authenticity and to avoid the inter observer error, all the morphometric measurements were done by the single independent personnel at the IMAGE (version 14.01) (Everrtech Software Private Limited, Mumbai, India) work station. Radial inclination, radial height, and ulnar variance were measured on PA view, and the measurement of palmer tilt was accomplished on the lateral view. All the statistical analysis was done by Microsoft XL 2007 (data add in function were installed for data analysis). *T*-test was used for comparing the means of the parameters and the level of significance set for the  $P < 0.05$ . Data were as analyzed as a whole population and in the groups also (right side and left side group, male and female gender group).

For subtending the angle of radial inclination on PA view, first we drew the line from the tip of the radial styloid of the radius to the medial edge of the distal radius (line A-B) then the second horizontal line drawn (line B-C) perpendicular to the longitudinal axis of the radius (line D-E) at the level of the lunate fossa [Figure 1]. Thus, the subtended angle ( $\angle ABC = \angle a$ ) is the angle of radial inclination. Palmer tilt was measured on lateral radiographs by drawing a line connecting the dorsal and palmer edge (line A-B) of the articular surface of the DER, then a perpendicular line (line B-C) from the palmer edge of the articular surface to the long axis (Line D-E) at the level of radial styloid process of the radius. Thus, the subtended angle ( $\angle ABC = \angle b$ ) is the angle of palmer tilt [Figure 2]. For measuring the radial height in

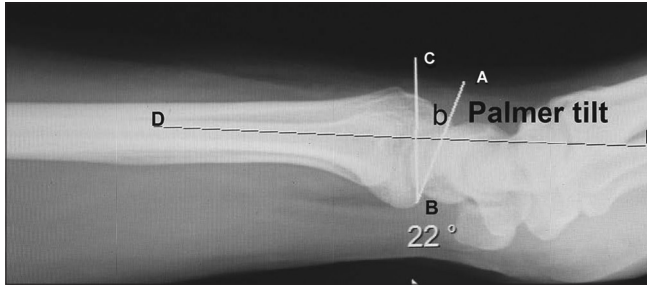


**Figure 1:** Radial inclination (a) is measured as an angle made by the tangential line connecting the radial styloid to the medial edge of the distal radius (A-B) and the horizontal line perpendicular to the axis of radius at the level of lunate fossa (B-C)

PA view, the first horizontal line (line A-B) drawn on the line perpendicular to the long axis of the radius (line C-D) passing through the distal tip of the radial styloid, and the second horizontal line drawn to perpendicular to the long axis of the radius passing through the lunate fossa (line E-F). Now, the length (h) between the two horizontal lines (line A-B to line E-F) is radial height [Figure 3]. Ulnar variance was also measured on PA radiographs. Moreover, it is a distance (h) measured between the line A-B drawn at the cortical margin (perpendicular to the long axis, line E-F) of the distal ulna relative to the line C-D drawn at the cortical margin (perpendicular to the long axis, line G-H) of the distal radius [Figure 4]. Measured values of ulnar variance were designated as positive or negative according to the relative distal or proximal position of the distal ulnar cortical margin (compared to the distal radial cortical margin), respectively.

**RESULTS**

Two hundred and forty two ( $n = 242$ ) X-rays were included in this study to analyze. The male and female ratio was of 170 (70.24%) male and 72 (29.76%) female patients. The right and left distribution was of 86 left (28 female, 58 male) and 156 right (44 female, 112 male). Age of the patients ranges from 17 to 65 years with an average of  $33.58 \pm 22.36$  (standard deviation [SD]) years old.



**Figure 2:** Depictions of measurement of palmer tilt (b). Angle is formed by the meeting point of two lines, one tangential line connecting to the dorsal and palmer edge of the articular surface of distal end radius and the second line perpendicular to the long axis of the radius at the level of radial styloid process



**Figure 3:** Radial height is the distance measured from the horizontal line (perpendicular to the axis of the radius at the level of lunette fossa) to the horizontal line perpendicular to the axis of the radius at the level of radial styloid process

The analytic outcomes of the study in the various perspectives are depicted in Tables 1-3. The average value ( $n = 242$ ) of radial inclination was  $23.27^\circ \pm$  (SD)  $7.42^\circ$  (range:  $11.3-42.1^\circ$ ), palmer tilt  $10.07^\circ \pm$  (SD)  $5.28^\circ$  (range:  $1-16.9^\circ$ ), radial height  $11.31 \text{ mm} \pm$  (SD)  $4.9 \text{ mm}$  (range:  $7.1-30.4 \text{ mm}$ ), and ulnar variance  $0.66 \text{ mm} \pm$  (SD)  $2.46 \text{ mm}$  (range:  $-2.4$  to  $+4.1$ ) are [Table 1].

The values (average  $\pm$  SD) of the radial inclination  $23.18 \pm 7.98^\circ$ , palmer tilt  $10.14 \pm 5.22^\circ$ , radial height  $11.66 \pm 5.34 \text{ mm}$ , and ulnar variance was  $00.55 \pm 2.34 \text{ mm}$  for the male gender. Moreover, the values (average  $\pm$  SD) for the female gender were radial inclination  $23.49 \pm 5.92^\circ$ , palmer tilt  $9.9 \pm 5.44^\circ$ , radial height  $10.48 \pm 3.14 \text{ mm}$ , and ulnar variance  $0.93 \pm 2.7 \text{ mm}$  [Table 2]. However, the differences were not significant statistically, except the radial height which showed the statistical difference of  $P < 0.05$  (0.0032).

Measurements of parameters for the right side had the values for the (average  $\pm$  SD) radial inclination  $23.18 \pm 7.84^\circ$ , palmer tilt  $10.48 \pm 5.16^\circ$ , radial height  $11.27 \pm 3.62 \text{ mm}$ , and ulnar variance  $0.77 \pm 2.54 \text{ mm}$ , respectively. Furthermore, the left side had the values for the (average  $\pm$  SD) radial inclination  $23.42 \pm 6.72^\circ$ , palmer tilt  $9.30 \pm 5.24^\circ$ , radial height  $11.36 \pm 6.76 \text{ mm}$ , and ulnar variance  $0.47 \pm 2.34$ , respectively [Table 3]. Moreover, the comparison of the parameters of the left and right side also did not reveal any statistically significant differences.

**Table 1: Distribution of radial inclination, palmar tilt, radial height, and ulnar variance in  $n=242$  subjects**

Parameter	Mean $\pm$ SD (range)
Radial inclination ( $^\circ$ ) (range)	23.27 $\pm$ 7.42 (11.3-42.1)
Palmar tilt ( $^\circ$ ) (range)	10.07 $\pm$ 5.28 (1-16.9)
Radial height (mm) (range)	11.31 $\pm$ 4.9 (7.1-30.4)
Ulnar variance (mm) (range)	0.66 $\pm$ 2.46 (-2.4-+4.1)

SD=Standard deviation

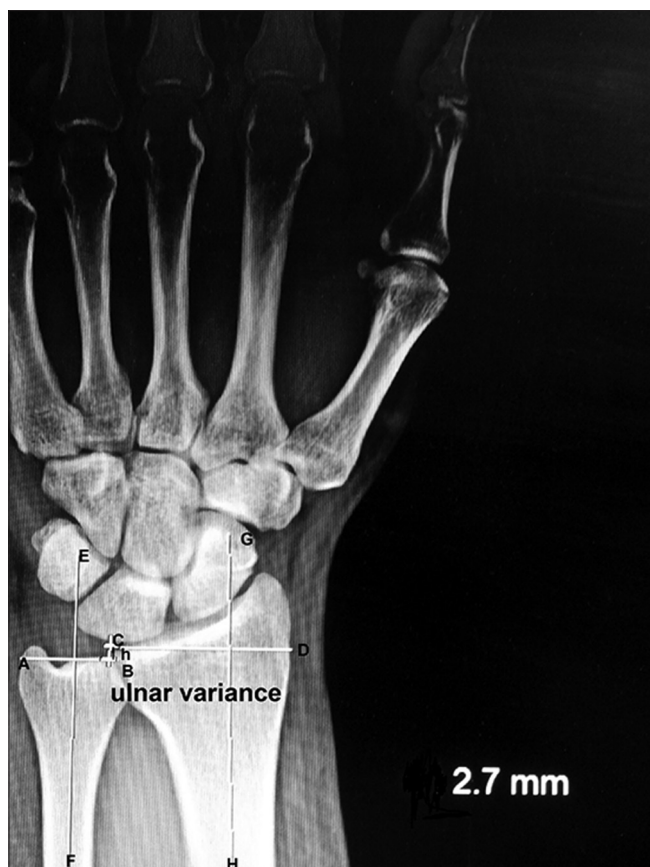
**Table 2: Distribution of morphometric parameters (average $\pm$ standard deviation) in genders**

Parameters	Male	Female	P
Radial inclination ( $^\circ$ )	23.18 $\pm$ 7.98	23.49 $\pm$ 5.92	>0.05
Palmar tilt ( $^\circ$ )	10.14 $\pm$ 5.22	9.9 $\pm$ 5.44	>0.05
Radial height (mm)	11.66 $\pm$ 5.34	10.48 $\pm$ 3.14	<0.05 (0.0032)
Ulnar variance (mm)	00.55 $\pm$ 2.34	0.93 $\pm$ 2.7	>0.05

**Table 3: Distribution of morphometric parameters for left and right side**

Parameters	Mean $\pm$ SD		P
	Right	Left	
Radial inclination ( $^\circ$ )	23.18 $\pm$ 7.84	23.42 $\pm$ 6.72	>0.05
Palmar tilt ( $^\circ$ )	10.48 $\pm$ 5.16	9.30 $\pm$ 5.24	>0.05
Radial height (mm)	11.27 $\pm$ 3.62	11.36 $\pm$ 6.76	>0.05
Ulnar variance (mm)	0.77 $\pm$ 2.54	0.47 $\pm$ 2.34	>0.05

SD=Standard deviation



**Figure 4:** Ulnar variance is the distance measured between the two horizontal lines. One perpendicular to the axis of ulna at the distal cortical margin and the second line perpendicular to the axis of radius at the distal cortical margin

## DISCUSSION

In the clinical practice, mostly orthopedic surgeons have been conceded the available reference values of Gartland and Werley as a standard value to treat the injuries of DER.<sup>8</sup> However, the literature is illuminating the radiographic study for the morphometry of the DER of their country's population. The morphometric parameters of DER vary among the races. So the unawareness of this fact may be responsible for the orthopaedists to adopt the only available Western data of morphometric parameters of DER. The study of the Chan *et al.* of the Malaysian population found that the ulnar variance is statistically (significant) variable in the Chinese and Malaysian population.<sup>9,10</sup>

The use of radiography as a tool for evaluating the morphometric measurements of the DER have been criticized by the few authors. A cadaveric study of Johnson and Sazbo found that palmer tilt is influenced by the rotation. Hence, in a lateral view radiograph, the 5° of rotation is responsible for the 1.6° of alteration in the palmer tilt. In a subsequent study of Pennock *et al.* has shown the effect of forearm rotation over the radial

inclination, radial height, and palmar tilt. They found that supination increases the apparent measurements and forearm pronation decreases the apparent measurements significantly.<sup>11,12</sup> Since our study was the prospective study, so during the forearm positioning we tried to keep the limb in neutral rotation to neutralize the effect of pronation and supination. It is obvious that population in the cadaveric study tends to be older than the general population, while our study has almost homogenous age distribution, so the our study is superior. It is very reasonable to assume that there are higher chances to include the pathologic bone in the study, due to unavailability of the history of cadavers. However, the question becomes very important that how the cadaveric (osteometric) morphometric values will be translated in the clinical practice, where the perspective of acceptance and non acceptance is purely radiological. Or in second hand, we can say that clinically the quality of reduction is assessed mainly by the radiological restoration of angle of radial inclination and palmer tilt.

Reciprocation between the morphometry of DER and functional after effect following the fracture reduction and biomechanics of wrist joint has been well mentioned in the literature. Miyake *et al.* Studied over the twenty cadavers (artificially created dorsal angulation at the wrist) and found that in the neutral position the force concentrated at the volar regions of the radiolunate joint and if the dorsal angulation is increased then the stress shifted to the dorsal region of radiolunate joint.<sup>13</sup> Pogue also found the almost same result.<sup>14</sup> Subsequently, the Short *et al.* depicted the changes of stress transfer and found that the dorsal angulation increases the force transmitted through the ulna so that at 30 degrees of dorsal angulation results into 50% increased weight bearing by ulna.<sup>15</sup>

Gelberman *et al.* established that the negative ulnar variance is (statistically significant) liable for the Kienbock's disease, which is more common in whites.<sup>16</sup> Even the domain of negative ulnar variance over the avascular necrosis of the lunate, avascular necrosis of scaphoid, and scapho-lunate dissociation have also been proved by the study of DeSmet.<sup>17</sup> Contrariwise the positive ulnar variance causes superabundant loading over ulnar compartment, which leads to triangular fibrocartilage complex (TFCC) degeneration, perforation, and further causes degeneration on carpal bone cartilage. In a laboratory setting of Adams, the radial shortening is mostly distorting TFCC and caused the greatest disturbance in the kinematics around the wrist. Radial inclination also does the same but of meager value.<sup>18</sup>

The fracture incidence of the lower end of radius prevails up to the 8–15% among all the fractures of the upper

limb.<sup>19,20</sup> Moreover, from the above discussion, it is evidential manifest that the morphometric study of the lower radius has an utter importance during the evaluation and treatment of the injuries involving the wrist area. Hence, the absolute knowledge of the normal values of morphometric parameters of the DER is imperative for managing the anatomical alignment.<sup>21</sup>

The limitations of the study are that it was a single center study (single observer) with the smaller population. Moreover, even the study had the unequal distribution of gender and side so that may affect the comparison of values. Hence, for the homogeneity, the further observational studies involving the multiple examiners are needed. In this study, we also compared the morphometric parameters of the right and left side. Because the few schools of thoughts never agree to use the present (existing) population as a reference parameter. As an example, the study of Hollevoet *et al.* (overfifty patients) variability of the left-right differences was compared with the variability of the whole group and was significantly less for radial inclination, ulnar variance, and palmar tilt. Hence, they suggested that contralateral wrist is the best parameter (reference value) for an individual for DER management, rather than population data.<sup>22</sup> However, our study did not show the [Table 2] statistical significant difference in the comparison of the left and right side.

Table 4 shows the comparison of the data. Among the studies, only the Werner *et al.* showed the highest radial height and palmer tilt.<sup>23</sup> The contemporaneous practice in India is often times based on Western data and is not par excellence. From Table 5, it seems that it is not wise to use the parameters of Western literature because our parameters are quite different.

In our study, the radial inclination is 23.2° which is closer to most commonly used Orthopaedic Trauma Association criteria (23°) and the study of Schuind *et al.*<sup>24</sup> and Altissimi *et al.*<sup>25</sup> The mean value of radial inclination of our study

lies between the mean values of two Indian cadaveric studies by Gupta *et al.*<sup>6</sup> and Prithishkumar *et al.*<sup>7</sup> The radiographic study of Chan *et al.*<sup>10</sup> and cadaveric study of Werner *et al.*<sup>23</sup> have found the significantly higher values of radial inclination. The lowest value of palmer tilt is 6° in the study of Werner *et al.*,<sup>23</sup> while the study and other studies have the nearby same results. In our study, the mean value of radial height is comparable to the mean value of the radial height of the other studies mentioned in Table 5. The various studies are mentioning the negative mean value of ulnar variance, but our study depicted the positive ulnar variance, which coincides to the result (positive ulnar variance) of Malaysian study<sup>10</sup> done over the Indian race. Which emphasizes that Indian have positive ulnar variance.

Only few literature has mentioned the gender-specific distribution of morphometric parameters. In our study, only the radial height showed the statistical difference (gender specific), while the other parameters were statistically insignificant [Table 2]. In comparison to us, the study of Chan *et al.*<sup>10</sup> even also did not find the gender-wise variation among their reported parameters. However, it is also notable that they did not study the radial height too.

If we discuss the side (left and right) distribution of morphometric parameters, then our study did not reveal any significant statistical difference [Table 3] among the parameters. Among the available literature, either they have not discussed the left and right distribution or did not found any statistical difference of parameters. Only the study of Prithishkumar *et al.*<sup>7</sup> found that the right side has the more palmer tilt than the left side [Table 4] and the difference was statistically significant ( $P = 0.05$ ).

## CONCLUSION

This study may provide an inaugurator plinth to prosecute the further analytical research in the Indian population. Moreover, the data may also be used as a reference data for the anatomical alignment while treating the injuries of the

**Table 4: Comparison between our study and other earlier reported studies**

Morphometric parameters of the distal end radius	Our study in India	Gupta <i>et al.</i> 2015 (Indian cadaveric study) <sup>6</sup>	Prithishkumar <i>et al.</i> 2012 (Indian cadaveric study) <sup>7</sup>	Chan <i>et al.</i> (Indian race) 2008 <sup>10</sup>	Schuind <i>et al.</i> , 1992 <sup>24</sup>	Werner <i>et al.</i> , 1992 (cadaveric study) <sup>23</sup>	Altissimi <i>et al.</i> , 1986 <sup>25</sup>	Gartland and Werley 1951 <sup>8</sup>
Radial inclination (°)	23.27±7.42	Total: 25.05 Left side: 24.0 Right side: 25.6	Left side: 21.8±2.5 Right side: 22.1±2.9	27±3.18	24 (19-29)	30	16-28	23 (13-30)
Palmer tilt (°)	10.07±5.28	Not reported	Left side: 8.2±2.9 Right side: 9.1±2.0 ( $P=0.05$ )	13±3.57	Not reported	6	0-18	11 (1-21)
Radial height (mm)	11.31±4.9	Left side: 10±0.13 Right side: 9.7±0.14	Left side: 11±1.4 Right side: 10.8±1.5	Not reported	Not reported	Not reported	Not reported	Not reported
Ulnar variance (mm)	0.66±2.46	Not reported	Not reported	0.13±0.70	-4.2-+2.3	-40.1-1.4	-2.5-+3.1	Not reported

**Table 5: Comparison between distal end radius morphometric measurements in our study (both right and left side) and the reference value used by the Orthopaedic Trauma Association**

Parameters	Our study	OTA reference value
Radial inclination (°)	11.3-42.1	13-30
Palmer tilt (°)	1-16.9	1-21
Radial height (mm)	7.1-30.4	11-13
Ulnar variance (mm)	-2.4-+4.1	Neutral

OTA=Orthopaedic Trauma Association

DER in Indian population. The distinct apprehension of the normal distribution of morphometry in a population (racial) group is utmost needed for the clinical practice. Hence, probably the study over the very large population, with racial consideration and comparing the radiographic and cadaveric morphometric parameters would be better to define the normal parameters of DER in the Indian population.

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Nil.

### Conflicts of interest

There are no conflicts of interest.

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