



Comparison of radiological and functional outcome of unstable intertrochanteric femur fractures treated using PFN and PFNA-2 in patients with osteoporosis

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Abstract

Introduction Presently, unstable intertrochanteric femur fractures are treated commonly with intramedullary nailing devices. Various designs of intramedullary nail are introduced. The conventional Proximal Femoral Nail has given diverse outcome. Complications have also been noted with this implant. Newer designs like Proximal Femoral Nail Antirotation-2 have been introduced for Asian population. The aim of our study was to compare the radiological and functional outcome of unstable intertrochanteric femur fracture treated with conventional Proximal Femoral Nail and Proximal Femoral Nail Antirotation-2 in osteoporotic patients.

Materials and methods Patients presenting with unstable intertrochanteric femur fracture (AO classification) and Singh's index ≤ 3 were included. Patients were assigned to the groups based on the implant used for treatment (PFN and PFNA2 group). Post-operative radiographs were used to assess the quality of reduction, by calculating neck shaft angle. The quality of fixation was assessed, by calculating tip apex distance and Cleveland index. The duration of surgery, blood loss, number of fluoroscopic images taken and length of hospital stay were noted. Patients were followed up for 6 months, and complications were noted. The functional outcome was compared using modified Harris hip score. The data analysis was done using Student's unpaired *t* test/Mann–Whitney *U* test and Chi-square test/Fisher's exact test. A *p* value less than 0.05 was considered significant.

Results Seventy-eight patients with unstable intertrochanteric fractures and Singh's index ≤ 3 were included. Thirty-seven were treated with PFNA2 and 41 with PFN. The average age in PFNA2 group was 69.51, and PFN group was 70.804. Nine patients in PFNA2 group and 10 patients in PFN group had tip apex distance more than 25 mm. Twelve patients in PFNA2 group and 14 Patients in PFN group had sub-optimal implant position as per Cleveland index. The difference in neck shaft angle between uninjured and operated side was more than 10° in four patients of PFNA2 group and seven patients of PFN group. The average Harris hip score was 74.55 for PFNA2 group and 69.88 for PFN group. Four complications were seen in PFNA2 group and 5 in PFN group.

Conclusion The functional outcome ($p=0.102$) achieved with both the implants was similar. Good functional outcome can be achieved, when the radiological parameters are restored, i.e. TAD < 25 mm, Cleveland index in centre–centre position and neck shaft angle difference $< 5^\circ$. The overall complications, in the set-up of osteoporosis, seen with both the implants were similar ($p=0.44$). PFNA2 group showed better results in terms of perioperative morbidity.

Keywords Intramedullary nailing · Singh's index · Neck shaft angle · Tip apex distance · Cleveland index

Introduction

There exists a debate regarding the treatment of unstable intertrochanteric femur fractures in the set-up of osteoporosis. The ideal implant for treating these fractures has been controversial. Intertrochanteric femur fractures are commonly seen in elderly people, and surgical fixation is the

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accepted way for managing these fractures to attain acceptable reduction and early mobilization after surgery [1]. Achieving stable fixation is very important in these patients as implant failure will lead to untoward complications and revision surgery will be difficult in these patients with poor general condition [2]. Studies have shown good results with intramedullary nailing for unstable intertrochanteric fractures [3, 4].

Various designs of intramedullary nail are available for treating unstable fractures like PFNA2 (Proximal Femoral Nail Antirotation-2) with single compression screw and PFN (Proximal Femoral Nail) with compression screw coupled with derotation screw. PFN has shown better outcome, but complications have also occurred [5].

PFNA2 has been designed to provide better stability for such fractures, in the presence of osteoporotic bone and consist of an intramedullary nail, both short and long versions, with proximal medio-lateral angulation of 5°. Inserting the PFNA2 blade without reaming the head and neck fragment, compacts the cancellous bone providing extra anchoring, which is important in osteoporotic bone [6].

Studies have shown that helical blade has better resistance against rotation and varus collapse [7]. Further studies are needed to confirm whether this property is beneficial in functional outcome and complication rates. The complications with helical blade are cut through into hip joint, back out like other implants [8]. Many studies have compared the conventional PFN with PFNA [9–11]. Limited studies are available on the newer design PFNA2 [12]. The purpose of the study was to compare the clinico-radiological outcome of PFNA2 and PFN in the surgical treatment of unstable intertrochanteric femur fracture, in patients with osteoporosis.

Materials and methods

A descriptive longitudinal study was conducted between January 1 2017 and July 1 2018 on 83 patients with unstable intertrochanteric fracture coming to Department of Orthopaedics in Wenlock district hospital, Kasturba Medical College and its allied hospitals in Mangalore. The study was conducted following the approval from Institutional Ethics Committee.

Patients with stable fracture as per AO classification [13] and previous implants in fractured hip were excluded. From the preoperative radiograph, fracture pattern was classified and patients with unstable fracture and Singh's index ≤ 3 [14] were included. To avoid bias, X-ray was seen by two Orthopaedic consultants.

Based on the implant, patients were divided into two groups, i.e. PFN and PFNA2. Randomization was done by alternate allocation of the patients into the groups. The

surgeries were conducted by Orthopaedic consultants with more than 3 years of clinical experience. During surgery, blood loss, duration and number of fluoroscopic images were noted down. The length of hospital stay was noted in both groups. Post-operatively, quality of reduction was assessed by comparing neck shaft angle of operated hip to that of normal hip from the radiographs. The difference of less than 5° was considered excellent, 5°–10° as good and more than 10° as poor reduction [15]. Quality of fixation was assessed using tip apex distance [16]. The Cleveland index [17] was used to note the position of the tip of compression screw. The measurements were done by two trained assistants using MB ruler in computed radiographic system of our hospital, and average of two measurements was taken.

Complications (intra- and post-operative) during the follow-up period were noted. The functional assessment was done using modified Harris hip score [18]. In patients with malreduced post-operative X-ray and/or unsatisfactory screw position, non-weight bearing walker/crutch mobilization was started immediately after surgery. After 6 weeks, X-ray was done and partial weight bearing was started, as per pain tolerance. Two X-ray views were taken to assess the radiological outcome. Radiological union was described as bridging trabeculation at the fracture site, on two views, in the absence of complications.

Data analysis

The data were compared using Student's unpaired *t* test/Mann–Whitney test for quantitative measurements, and Chi-square test/Fisher's exact test for qualitative measurements. A *p* value below 0.05 was considered significant. The data were entered in MS Excel spreadsheet, and statistical analysis was done using Statistical Package for Social Sciences (SPSS) version 16.0.

Results

Eighty-three patients were enrolled in the study, and five patients expired before the final follow-up due to other comorbidities. Seventy-eight patients with unstable intertrochanteric femur fracture and osteoporosis (Singh's index ≤ 3) were followed up for 6 months. Thirty-seven patients were treated with PFNA2 and 41 patients with PFN (Table 1). The average age in PFNA2 group was 69.15 and 70.80 for PFN group. The age distribution difference between two groups was not significant ($p=0.253$). In PFNA2 group, 20 were males and 17 were females. In PFN group, males were 19 and 22 were females.

As per Singh's index, in PFNA2 group, 16 had grade 3, 13 had grade 2, and 8 had grade 1 osteoporosis. In PFN group, 20 had grade 3, 12 had grade 2, and 9 had grade

Table 1 Demographic statistics

	PFNA-2 group (37)	PFN (41)
Age (Average)	69.51	70.80
Sex		
Male	20 (54.05)	19 (46.34)
Female	17 (45.95)	22 (53.66)
Singh's index		
Grade 3	16 (43%)	20 (49%)
Grade 2	13 (35%)	12 (29%)
Grade 1	08 (22%)	09 (22%)
AO classification		
31. A2	27	29
31. A3	10	12

Table 2 Operative details

	PFN (n=41) Mean ± SD	PFNA2 (n=37) Mean ± SD	p value
Duration (min)	44.02 ± 5.83	34.45 ± 5.5	<0.001
Blood loss (ml)	70.24 ± 15.57	51.35 ± 13.36	<0.001
Fluoroscopy (no.)	32.46 ± 2.45	27 ± 3.04	<0.001
Length of hospital stay (days)	7.34 ± 1.65	6.64 ± 1.41	0.048

1 osteoporosis. This distribution between two groups was not significantly different ($p = 0.8441$). All 78 patients have unstable fracture as per AO classification. In PFN group, 12 patients and 10 patients of PFNA2 group had 31. A3 type fracture (Table 1).

The mean duration of surgery for PFN group was 44.02 min, while 34.45 min for PFNA2 group ($p < 0.001$) (Table 2). The mean blood loss in PFN and PFNA2 group was 70.24 ml and 51.35 ml, respectively ($p < 0.001$). The mean value of fluoroscopic images used for PFN and

PFNA2 group was 32.46 and 27, respectively ($p < 0.001$). The mean value of length of hospital stay for PFN group was 7.34 days, whereas it is 6.64 days for PFNA2 group ($p = 0.048$) (Table 2).

Neck shaft angle (NSA)

22/37 in PFNA2 group and 17/41 in PFN group had excellent reduction (difference in NSA between operated to normal hip— $< 5^\circ$) ($p = 0.279$) (Table 3). 11/37 in PFNA2 group and 17/41 in PFN group had good reduction (5° – 10°). Four patients in PFNA2 group and seven patients in PFN group had poor reduction. All four patients with poor reduction in PFNA2 group had poor functional results. Two out of four complications seen in PFNA2 group had poor reduction ($> 10^\circ$). These two were complications related to implant failure. The four implant-related complications seen in PFN group had good reduction (5° – 10°). Four out of seven patients with poor reduction in PFN group had poor functional outcome, and remaining three patients had fair results.

Tip apex distance (TAD)

9/37 in PFNA2 group and 10/41 in PFN group had tip apex distance of more than 25 mm ($p = 0.99$) (Table 3). Only 1/4 patients, with implant-related complications, in PFN group had TAD more than 25 mm, and 3/4 patients had TAD in the range of 20–25 mm. 1/2 patients, with implant failure, in PFNA2 group had TAD more than 25 mm. Out of nine patients, with TAD > 25 mm in PFNA2 group, five patients had poor functional outcome, two had fair, and two had good results. Out of 10 patients, with TAD > 25 mm in PFN group, eight had poor functional outcome and two had good results.

Table 3 Summary of results

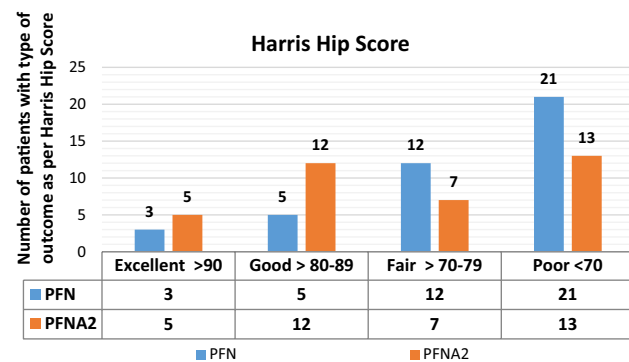
n=78	PFNA-2 group (37)	PFN group (41)	p value
Harris hip score (final follow-up average)	74.55	69.88	0.102
Tip apex distance (> 25 mm)	9	10	0.99
Cleveland index (sub-optimal position)	12	14	0.438
Neck shaft angle (difference between $< 5^\circ$ operated and normal side)			
$< 5^\circ$	22	17	0.279
5° – 10°	11	17	
$> 10^\circ$	4	7	
Radiological union	28	29	0.602
Overall complications	4/37	5/41	0.43
Implant failure	2	4	0.256

Table 4 Cleveland index of PFNA2 group (first number indicates complications, second number is the number of patients)

PFNA2(37)				
		Superior		
		1/1	1/1	
Anterior	0/4	0/23	0/6	Posterior
		0/2		
		Inferior		

Table 5 Cleveland index of PFN group

PFN (41)				
		Superior		
		1/3	0/1	
Anterior	2/7	0/24	0/3	Posterior
		1/3		
		Inferior		

**Fig. 1** Functional outcome by modified Harris hip score

Cleveland index

In PFNA2 group, 25/37 (67.56%) and in PFN group, 27/41 (65.85%) had optimal position of implant in the head of femur as per Cleveland index (centre–centre, inferior–centre) ($p=0.438$) (Table 3). Out of 12 patients with sub-optimal position in PFNA2 group, two had implant failure. Out of 14 patients with sub-optimal position in PFN group, three had implant failure. One patient with inferior–centre position showed implant failure (Tables 4, 5).

Functional outcome by modified Harris Hip score (Fig. 1)

The average Harris hip score at final follow-up in PFNA2 group was 74.55, and in PFN group it was 69.89 (Table 3). In PFN group, 3 had excellent results, 5 had good results,

Table 6 Complications

Complications	PFNA2 group	PFN group	Total
Screw back out	1	2	3
Screw cut out	1	2	3
Subtrochanteric fracture	1	–	1
Screw in the joint	1	–	1
Superficial infection	–	1	1
Total	4	5	9

12 had fair, and 21 had poor results. In PFNA2 group, 5 had excellent, 12 had good, 7 had fair, and 13 had poor results (Fig. 1). The average score in patients with complications of PFN group was 64.35, and in PFNA2 group it was 56.4.

Complications in both group

PFNA2 group had overall four complications, and PFN group had five complications. 4/5 complications in PFN group and 2/4 in PFNA2 group were due to implant failure (Table 6). In PFNA2 group, 1 had screw back out (Fig. 2), 1 had screw cut out, 1 had subtrochanteric fracture (Fig. 3), and 1 had screw in the joint. In PFN group, two patients had screw back out (Fig. 4), two had screw cut out, and one had superficial infection. The superficial infection in PFN group was healed with regular dressing (Fig. 5).

Discussion

The unstable intertrochanteric femur fractures in elderly with osteoporosis need early fixation and mobilization to prevent morbidity and mortality. The intramedullary device has many advantages in terms of small surgical wound, easy implant insertion and stable fixation [19]. The purpose of the study was to compare the outcome of PFN and PFNA2 in unstable intertrochanteric fracture in elderly patients with osteoporosis. There was no difference in age distribution and Singh's index between two groups. There were 39 males and 39 females. Males were more in PFNA2 group and females in PFN group.

The perioperative morbidity was assessed by noting the duration of surgery, blood loss and number of fluoroscopic images taken. When results of both groups were compared, there was significant correlation. PFNA2 showed better results. Even the length of hospital stay in PFNA2 group was less than PFN group. Zeng et al. [20] and Takigami et al. [21] found that operative time and blood loss were lower with PFNA as compared to PFN. The results of our study are comparable with these studies. The duration of surgery and number of fluoroscopic images were significantly lower

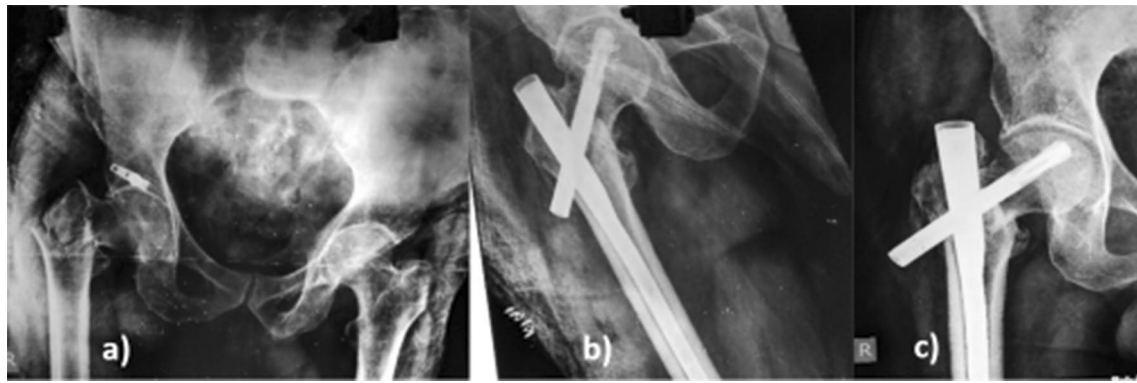


Fig. 2 PFNA2 with screw back out. **a** Preoperative shows unstable IT fracture, **b** post-operative X-ray, and **c** follow-up X-ray shows varus collapse and screw back out

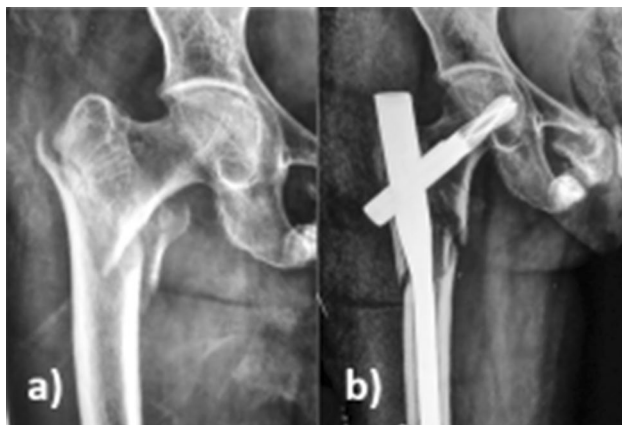


Fig. 3 PFNA2 with intraoperative complication of subtrochanteric fracture. **a** Preoperative and **b** post-operative X-ray

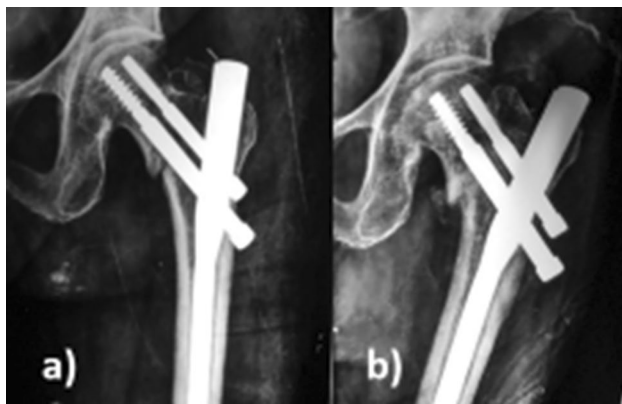


Fig. 4 PFN with screw back out. **a** post-operative X-ray—fracture fixed with PFN, but calcar was not restored, **b** follow-up X-ray shows fracture union with screw back out

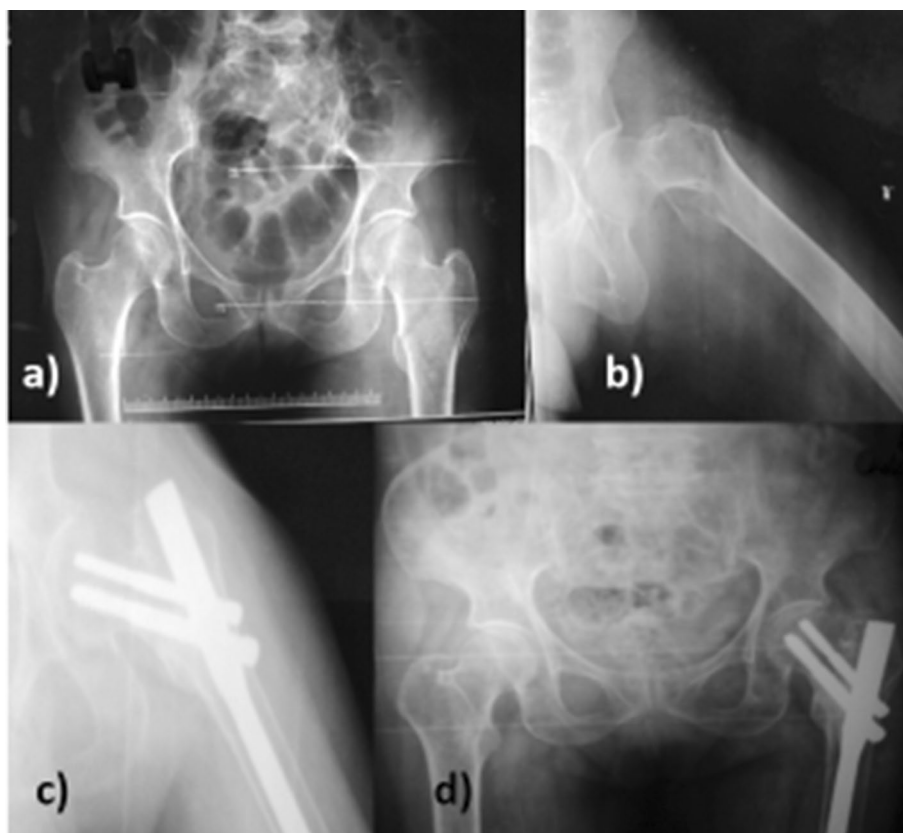
in PFNA2 group due to use of single helical blade in PFNA2 as compared to two screws in PFN. The mean blood loss was lower in PFNA2 group due to decreased operative time and smaller incision for the placement of PFNA2 blade.

When tip apex distance was more than 25 mm in both groups, there were more patients with poor functional outcome (eight in PFN and five in PFNA2 group). This suggest that maintaining a tip apex distance of less than 25 mm is necessary to achieve better functional outcome at follow-up. Nikoloski et al. [8] recommended a tip apex distance of 20–30 mm in case of PFNA-2. They observed a higher incidence of cut out/cut through, when TAD was more than 30 mm or less than 20 mm.

As per the Cleveland index, maintaining an optimal position (centre–centre, inferior–centre) of the screw is necessary for good outcome [17]. Complications were more when the screw position was in sub-optimal position in both groups. When the index was centre–centre in both groups, no complications were seen and had better outcome. Only 1 case in PFN group with inferior–centre index showed complication of screw back out. Maintaining the neck shaft angle difference between operated and normal side, less than 5° is necessary to get better results [22]. When the difference was less than 5° in both groups, outcome was good. The complications seen in PFNA2 group had poor reduction (> 10°), and in PFN group, the difference was more than 5°.

The overall functional outcome in both groups, when compared, had similar results, although functional outcome was poor in 21 (51.21%) patients of PFN group and 13 (35.13%) of PFNA2 group. Kashid MR et al. found similar functional results between PFNA and PFN. PFNA significantly reduced surgery time, blood loss and fluoroscopy time [9]. Li et al. [23] compared the complication rates of PFNA2 and PFNA, in elderly Chinese population. He concluded that, PFNA2 will give better results and lesser rate of complications than PFNA. Similarly, Xie et al. [24] compared outcome of PFN-II and PFNA. PFNA-II had advantage of

Fig. 5 **a, b** Preoperative X-ray—AP and lateral view suggestive of unstable fracture, **c** post-operative X-ray—fracture fixed with PFN, and **d** follow-up X-ray shows radiological union



less duration of surgery, blood loss and fluoroscopy time, but functional results were similar. We compared PFN. We got similar functional results in PFNA and PFNA2 group, but PFNA2 had less perioperative morbidity.

Loo et al. [25] from their review article of 62 patients concluded that PFNA is better implant for stabilizing proximal hip fractures than PFNA2. We compared outcome of PFN and PFNA2 and found no significant difference between two groups with respect to functional outcome, and both the implants were effective in treating such fractures.

Hu et al. [26] suggested from their study that there was a morphological mismatch in Asian population between proximal fragment of PFNA 2 and greater trochanter leading to post-operative lateral trochanter pain. Lateral trochanter pain was noted in 15 patients in PFNA2 and 17 patients in PFN group at the final follow-up in our study. Kumar et al. [12] from their prospective suggested that PFNA 2 as effective implant in treating intertrochanteric fractures with proper operative techniques. Our study included 78 patients and found no difference in outcome of both the implants.

Kammerlander et al. [27] considered cement augmentation of the PFNA blade. Although it did not improve patients walking ability compared to non-augmented PFNA, it prevented complications by increasing the strength of the construct. All the PFNA2 cases in the present study were

non-augmented. To prevent potential complications of screw back out, cement augmentation can be considered.

The implant-related complications seen in both groups had either poor neck shaft angle reduction, tip apex distance more than 25 mm or Cleveland index in sub-optimal position. Hence, we recommend to restore TAD < 25 mm, Cleveland index in centre–centre position and neck shaft angle difference of < 5°.

Limitations of the study

All the surgeries were not performed by the same surgeon and short follow-up of 6 months.

Conclusion

The functional outcome achieved with both the implants were similar ($p=0.102$). Good functional outcome can be achieved, when the radiological parameters are restored, i.e. TAD < 25 mm, Cleveland index in centre–centre position and neck shaft angle difference < 5°. The overall complications, in the set-up of osteoporosis, seen with both the implants were similar ($p=0.44$). PFNA2 group showed better results in terms of perioperative morbidity.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no competing interests.

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