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Orapuh Journal

ORIGINAL ARTICLE

Journal of Oral & Public Health

Exploratory study of posterior lumbar disc herniation using low-field magnetic resonance imaging in hospital settings in Kinshasa: Case of the Diamant Medical Center

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ARTICLE INFO

Received: *01 February 2025*
Accepted: *06 March 2025*
Published: *24 April 2025*

Keywords:
Lumbar disc herniation, MRI, disc degeneration, Pfirrmann, low back pain

Peer-Review: *Externally peer-reviewed*

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To cite:
Iyoto, D. M., Tshibasu, F. T., Yanda, S. T., Kinkunda, P. L., Makwanza, L., Nsonde, G. N., Ndaie, G., Nseka, O. Z., Kombo, J. K., & Mukaya, J. T. (2025). Exploratory study of posterior lumbar disc herniation using low-field magnetic resonance imaging in hospital settings in Kinshasa: Case of the Diamant Medical Center. *Orapuh Journal, 6*(4), e1235
https://dx.doi.org/10.4314/orapj.v6i4.35

ISSN: *2644-3740*

Published by Orapuh, Inc. (info@orapuh.org)

Editor-in-Chief: Prof. V. E. Adamu
Orapuh, Inc., UMTG PMB 405, Serrekunda, The Gambia, editor@orapuh.org.

ABSTRACT

Introduction
The limited availability of advanced medical technologies, combined with the rising prevalence of degenerative disc disease, presents a significant challenge in sub-Saharan Africa. Lumbar disc herniation requires reliable imaging for accurate diagnosis and appropriate treatment.

Purpose
This study explores posterior lumbar disc herniation (LDH) using low-field magnetic resonance imaging (MRI) in hospitals in Kinshasa.

Methods
A single-center, cross-sectional analytical study was conducted on 81 patients who underwent lumbar spine MRI examinations for chronic low back pain over 14 months, from December 2022 to January 2023, at the Diamant Medical Center (DMC).

Results
Lumbar disc herniation was more common in men (50.6%), with the highest prevalence in the 50–65-year age group (30%). Disc desiccation was present in all segments and statistically increased with age ($p < 0.05$). Disc bulging was most frequently observed at L5–S1 (20% of cases), followed by disc protrusion at L4–L5 (14.8% of cases). Only disc bulging and protrusion were significantly associated with disc desiccation at L4–L5, with the latter being more than six times more likely to present with protrusion at L4–L5.

Conclusion
Disc desiccation remains the central feature of degenerative disc disease. More common in men, it can affect all disc segments at any age, with a higher prevalence in older adults, and can lead to disc displacement, such as bulging and protrusion, particularly in the lower lumbar spine.

INTRODUCTION

Lumbar disc herniation (LDH) is a global health issue, affecting a diverse population across different regions of the world (Diarra, 2002). Understanding its impact and prevalence is essential for establishing prevention strategies in its management (Lecouvet et al., 2017). LDH is classified among degenerative spinal pathologies, with disc desiccation (IDD) as its central feature. IDD is defined as a process characterized by an alteration in the structure and function of the intervertebral disc (IVD), often associated with aging, trauma, or overuse, which can lead to a loss of disc height, changes in composition, and decreased functionality (Urban & Winlove, 2007).

Furthermore, some studies have shown that degenerative damage to the lumbar spine, with frequencies ranging from 29.59% to 40%, is relatively common (Fujii et al., 2019). Polymorphic and often multifactorial, lumbar IDD eventually manifests in 80% of the Western population. Common low back pain (LBP) and radiculalgia, which may resolve spontaneously or with medical treatment, do not necessarily require imaging examinations. However, imaging is recommended for persistent symptoms unresponsive to standard analgesic treatments (Fujii et al., 2019; Hiwatashi et al., 2004; Malik et al., 2013).

Despite extensive knowledge of the IVD structure, LDH remains one of the primary causes of LBP (Urban & Winlove, 2007). According to some studies, LDH may account for 1–30% of LBP cases, with root involvement observed in 25% of patients. Magnetic resonance imaging (MRI) has significantly improved the diagnosis of this pathology by providing detailed images of the spine's soft tissues, thus facilitating patient management (Lecouvet et al., 2017; Hiwatashi et al., 2004). However, in resource-constrained settings, low-field MRI presents a promising alternative. Being more cost-effective than high-field MRI, low-field MRI offers a viable diagnostic solution in resource-limited hospital environments.

Despite its relevance, no study has specifically explored the use of low-field MRI in diagnosing lumbar degenerative disc disease (DDD) in our country. This study seeks to address this gap by investigating viable and accessible diagnostic solutions to improve patient care. The study aims to evaluate the MRI profile of LDH, determine the demographic characteristics of Congolese patients with chronic low back pain, assess the performance of low-field MRI in staging lumbar IDD, and classify IDD stages according to disc segments and age. This analysis will enhance the understanding of lumbar IDD in low-field MRI and its role in managing LDH in our setting.

METHODS

Study Area

This retrospective, analytical, and cross-sectional study was conducted at the Diamant Medical Center (DMC) in Kinshasa, a private health facility located at 2366 Colonel Monjiba, Commune of Ngaliema. The study covered a 14-month period from September 2022 to December 2023.

Study Population

Study participants were patients diagnosed with LDH via lumbar spine MRI after presenting with chronic low back pain. These patients were referred from various healthcare facilities in Kinshasa for MRI evaluation.

A total of 1,000 patients with chronic low back pain (from DMC and other healthcare facilities) were screened for study eligibility. Of these, 221 underwent lumbar spine MRI, and 81 were diagnosed with LDH. In total, 405 lumbar disc segments were assessed in the study. The participants were randomly selected from hospital records of patients who had undergone MRI.

Eligibility Criteria

Inclusion Criteria

Patients with chronic low back pain who underwent lumbar spine MRI, with or without radiculalgia of the lower limbs.

Exclusion Criteria

i. Patients with a history of spinal trauma, surgery, congenital malformations, inflammatory or tumoral spinal pathologies.

ii. Claustrophobic patients or those with metal implants or other contraindications to MRI.

Image Acquisition

Image acquisition was performed using a HITACHI APARTO LUCENT 0.4 Tesla MRI with a low open field and permanent magnetism. T1-weighted turbo spin echo

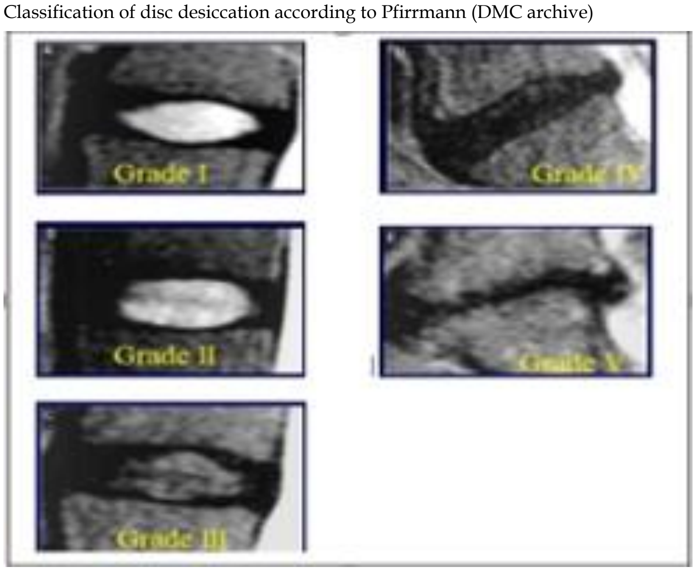
(TSE), T2-weighted TSE, and STIR sequences were performed on sagittal and axial slices. The acquisition parameters included sagittal T1-weighted TSE (TR 650 ms, TE 6.3 ms) and T2-weighted TSE (TR 4500 ms, TE 101 ms), sagittal STIR (TR 3800 ms, TE 35 ms, IR 215 ms), and axial T2 (TR 5000 ms, TE 116 ms) with a slice thickness of 4 mm and an inter-slice spacing of 1 mm. The sagittal sequences used a 320 mm field of view, with a 200 mm axial axis. Gadolinium injection was used when necessary.

MRI diagnosticians interpreted the images, correlating the sequences with vertebral disc degeneration as classified by the Pfirrmann system. The interpretation was based on T2-weighted median sagittal slices.

Operational Definitions

- **Age Categories:** Participants were categorized into three age groups: young (under 50 years), elderly (50–65 years), and very elderly (over 65 years).
- **Disc Changes:** Disc desiccation was assessed using the Pfirrmann classification, which categorizes degeneration into five grades based on disc structure, signal intensity of the annulus fibrosus and nucleus pulposus, disc height, and boundary clarity (Figure 1).

Figure 1:
Classification of disc desiccation according to Pfirrmann (DMC archive)



Observational Indicators

- **LDH:** A condition where the nucleus pulposus of the lumbar intervertebral disc extends beyond its normal limits, potentially compressing adjacent nerves and causing symptoms such as pain, numbness, or weakness (McGirt et al., 2009).
- **IDD:** A degenerative process affecting the IVD, leading to disc height loss, composition alteration, and reduced functionality (Urban & Winlove, 2007). IDD severity was graded using the Pfirrmann classification, which assesses structural integrity, signal intensity, disc height, and boundary clarity (Manchikanti, 2009).

Table 1:
Characteristics of Discs for Each Grade

Grade	Structure	Distinction of Nucleus and Annulus	Signal Intensity	Intervertebral Disc Height
I	Homogeneous, bright white	Clear	Hyperintense, isointense to cerebrospinal fluid	Normal
II	Inhomogeneous with/without horizontal bands	Clear	Hyperintense, isointense to cerebrospinal fluid	Normal
III	Inhomogeneous gray	Unclear	Intermediate	Normal to moderately decreased
IV	Inhomogeneous gray to black	Lost	Intermediate to hypointense	Normal to moderately decreased
V	Inhomogeneous black	Lost	Hypointense	Collapsed disc space

Data Collection

Data were obtained through a review of patient medical records from DMC. A pre-established form defined key study variables. To ensure quality, data collection was conducted by two trained DMC technicians under the supervision of the principal investigator.

Statistical Analyses

Data were entered using Microsoft Excel 2010, checked for consistency, and exported to SPSS 21 for analysis. Descriptive statistics included mean and standard deviation for quantitative data and percentages for categorical data. The chi-square test compared proportions, while the Student's t-test compared means. A p-value < 0.05 was considered statistically significant. Data confidentiality was ensured, with anonymized collection used solely for study purposes.

Ethical Considerations

The study protocol was submitted for approval to the scientific committee of the Department of Radiology and Medical Imaging and the ethics committee of the School of Public Health at the University of Kinshasa (Approval number: ESP/CE/079/2023).

RESULTS

A total of 81 patients were included in the study, comprising 41 males (50.6%) and 40 females (49.4%), with no significant gender predominance (sex ratio of 1.03). The mean age of the patients was 54.01 ± 16.8 years. There was no statistically significant difference between sex or age groups. Table 2 presents the distribution of patients by age and gender.

Table 2:
Distribution of patients by age and gender

Variables	Effective	%
Age group		
< 50 years	27	33.3
50 – 65 years	30	37.0
> 65 years	24	29.6
Mean age (years ± SD)	***54.01 ± 16.8***	
Sex		
Male	41	50.6
Female	40	49.4
Total	**81**	**100.0**

Types of Disc Desiccation by Disc Segment of the Lumbar Spine

Among the 405 disc levels of the 81 patients who underwent lumbar MRI for chronic low back pain, Pfirrmann grade II was the most prevalent, followed by grades III and IV in all segments. Grade V was not observed in the analyses. Table 3 provides the distribution of patients according to types of disc desiccation by lumbar spine segment.

Table 3:
Distribution of patients according to types of disc desiccation by lumbar spine segment

Pfirrmann	L1-L2		L2-L3		L3-L4		L4-L5		L5-S1		Total	
	n	%	n	%	n	%	n	%	n	%	n	%
I	8	9.8	7	8.6	4	4.9	3	3.7	10	12.3	32	7.8
II	**41**	50.6	**37**	45.6	**33**	40.7	17	20.9	23	28.3	**151**	**37.5**
III	17	20.9	23	28.3	27	33.3	**32**	39.5	21	25.8	**120**	**29.7**
IV	15	18.5	14	17.2	17	20.9	29	35.8	**27**	33.3	**102**	**25**
V	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Total	81	100	81	100	81	100	81	100	81	100	405	100

Distribution of Disc Desiccation by Disc Segment According to Age Group

Table 4 demonstrates that disc desiccation statistically increased with age across all discs evaluated ($p < 0.05$), except for the L5-S1 disc, where no significant difference was observed among the three patient age groups ($p = 0.127$).

Table 4:
Pfirrmann distribution by intervertebral disc according to age group

Variables		Age group						Total		
Segments	Pfirrmann	<50 years old		50-65 years old		>65 years old				P value
		n	%	n	%	n	%	n	%	
L1-L2										<0.001
	I	5	18.5	2	6.6	1	4.1	8	9.8	
	II	17	62.9	14	46.6	10	41.6	41	50.6	
	III	4	14.9	9	30.0	4	16.6	17	20.9	
	IV	1	3.7	5	16.8	9	37.7	15	18.5	
L2-L3										<0.001
	I	3	11.1	1	3.3	3	12.5	7	8.6	
	II	8	29.6	22	73.3	7	29.1	37	45.6	
	III	10	37.0	5	16.8	8	33.3	23	28.3	
	IV	6	22.3	2	6.6	6	25.1	14	17.2	
L3-L4										<0.001
	I	1	3.7	2	6.6	1	4.1	4	4.9	
	II	18	66.6	8	26.6	7	29.1	33	40.7	
	III	7	26.0	13	43.3	7	29.1	27	33.3	
	IV	1	3.7	7	23.5	9	37.7	17	20.1	
L4-L5										<0.001
	I	2	7.4	0	0.0	1	4.1	3	3.7	
	II	2	7.4	5	16.8	10	41.6	17	20.9	
	III	17	62.9	12	41.6	3	12.5	32	39.5	
	IV	6	22.3	12	41.6	11	41.8	29	35.8	
L5-S1										**0.127**
	I	2	7.4	3	10.0	5	20.8	10	12.3	
	II	5	18.5	12	41.6	6	25.1	23	28.3	
	III	11	40.7	5	16.8	5	20.8	21	25.8	
	IV	9	33.4	10	31.6	8	33.3	27	33.3	
Total		27	100	30	100	24	100	81	100	
Kruskal-Wallis test result										

Distribution of Disc Segments According to Disc Displacement

Disc bulging was the most common type of disc displacement, found in 124 segments (59.2%) out of 209 affected segments, followed by disc protrusion in 75 segments (35.9%). Table 5 presents the distribution of disc segments according to disc displacement.

Table 5:
Distribution of disc segments according to disc displacement

Disc Displacement	Effective	%
Diffuse		
Bulging	124	59.2
Focal		
Protrusion	75	35.9
Extrusion	10	4.8
Total	**209**	**100.0**

Disc Displacement Abnormalities at Each Disc Level

Table 6 reveals that disc bulging was most commonly observed at L5-S1 (20.0%), followed by disc protrusion at L4-L5 (14.8%). Disc extrusion was most frequently noted at L5-S1 (4.3%).

Table 6:
Frequency of disc displacement abnormalities at each disc level

	Disc displacement						
Segments	**Bulging disc**		**Disc protrusion**		**Disc extrusion**		**Total**
	n	*%*	*n*	*%*	*n*	*%*	*n(%)*
L1 – L2	5	2.4	3	1.4	0	0.0	8 (3.8)
L2 – L3	12	5.7	5	2.4	1	0.5	18 (8.6)
L3 – L4	27	13	16	7.7	0	0.0	43 (20.7)
L4 – L5	38	18.1	**31**	14.8	0	0.0	71 (32.9)
L5 – S1	**42**	20	20	9.6	**9**	4.3	71 (33.9)
Total	124	59.2	75	35.9	10	4.8	209 (100.0)

Association Between Disc Displacement and Desiccation of Intervertebral Discs

At the L1–L2, L2–L3, and L3–L4 levels, no significant association was found between disc desiccation and lumbar disc displacement ($p > 0.05$). However, at the L4–L5 level, a statistically significant association was observed between desiccation and disc bulging ($p = 0.035$), as well as between desiccation and disc protrusion ($p = 0.046$). A similar trend was noted at L5–S1 ($p = 0.025$ for disc desiccation and bulging, and $p = 0.046$ for disc desiccation and protrusion).

It was also observed that the likelihood of disc desiccation leading to disc bulging was six times higher at the L3–L4 level, four times higher at the L4–L5 level, and three times higher at the L5–S1 level. Additionally, the likelihood of disc desiccation resulting in disc protrusion was six times higher at the L4–L5 level and twice as high at the L5–S1 level.

Table 7:
Disc displacement and desiccation of intervertebral discs

Disc displacement	**Disc desiccation**		
	n (%)	P value	OR (95% CI)
L1 - L2			
Bulging	5 (6.2)	0.386	0.930 (0.872 – 0.991)
Protrusion	3 (3.7)	0.508	0.958 (0.912 – 1.006)
Extrusion	0 (0.0)	-	-
L2 – L3			
Bulging	12 (14.8)	0.669	1,600 (0.183 – 14.003)
Protrusion	5 (6.2)	0.653	0.597 (0.062 – 5.772)
Extrusion	1 (1.2)	0.076	0.113 (0.006 – 1.980)
L3 – L4			
Bulging	27 (33.3)	0.081	**5,523**(0.662 – 46.048)
Protrusion	16 (19.8)	0.857	1.164 (0.224 – 6.038)
Extrusion	0 (0.0)	0.777	1.111 (0.904 – 1.366)
L4 – L5			
Bulging	38 (46.9)	**0.035**	**3,894**(0.422 – 15.603)
Protrusion	31 (383)	**0.046**	6,049 (0.718 – 50.923)
Extrusion	0 (0.0)	0.441	1.125 (0.893 – 1.417)
L5 – S1			
Bulging	42 (51.9)	**0.025**	**3,281**(0.598 – 18.017)
Protrusion	20 (24.7)	**0.046**	2.222 (0.252 – 19.625)
Extrusion	9 (11.1)	0.328	0.878 (0.807 – 0.956)
Total	209 (100.0)	-	-

DISCUSSION

Patient Demographics Profile

The prevalence of degenerative disc disease (DDD) increases linearly with age, and by age 70, 80% of lumbar discs have deteriorated (Kalichman et al., 2009). However, the primary cause of intervertebral disc degeneration (IDD) is tissue weakening, which is mainly due to aging, poor diet, mechanical stress, and genetic predisposition (Erwin et al., 2015; Urban et al., 1977; Wang et al., 2017).

Our study showed that 54 out of 81 patients were aged 50 years and older, with a mean age (± SD) of 54 years (± 16.8), ranging from 4 to 83 years, with a male predominance. The age distribution of patients in our study is consistent with other studies, such as that of Dubuisson et al. (2013) in Sart-Tilman et al. (2012) in Hong Kong, China, who reported mean patient ages of 38, 41.1, and 56.4 years, respectively. Combining these data with previous interpretations, it is evident that DDD primarily affects

https://dx.doi.org/10.4314/orapj.v6i4.35

middle-aged adults, with a higher incidence in men than in women. The prevalence of degenerative disc disease appears to increase with age, peaking in patients aged 50 to 69 years (Samartzis et al., 2012; Wang et al., 2017).

Desiccation of the Intervertebral Disc

For each vertebral level of the lumbar spine (L1 to S1), there is variability in the prevalence of different IDD grades (Grades I, II, III, and IV). It is important to note that our study was conducted in an African population, which is predominantly young. This demographic factor may justify the absence of Pfirrmann Grade V in our observations.

Our analysis showed that Grade II predominated from L1 to L4, while Grade III was more prevalent at the L4-L5 level, and Grade IV was more common at L5-S1. This distribution varies across different spinal levels. Our findings align with those of Pfirrmann et al. (2001) in Zurich, who found 240 cases of Grade II and 82 cases of Grade III discs. IDD increases significantly with age across all evaluated discs ($p < 0.05$), except for the L5-S1 disc, where the Pfirrmann grade was statistically similar across the three age groups ($p = 0.127$) (Pfirrmann et al., 2001).

Additionally, there is a trend toward an increasing prevalence of IDD grades in the lower lumbar spine levels, with a more balanced distribution between Grades I, II, III, and IV. The upper (L1-L2, L2-L3) and mid-lumbar (L3-L4) levels experience less mechanical stress than the lower levels (L4-L5 and L5-S1) (Demers, 2015; Teraguchi et al., 2014; Thapa et al., 2016). In summary, this analysis provides insight into the distribution of different types of IDD in the lumbar spine and offers useful information for assessing degenerative changes in this region.

Disc Displacement

Thapa et al. (2016) in Nepal stated that the compressive disc load is transmitted from one vertebral endplate to another through the annulus fibrosus and nucleus pulposus. The nucleus pulposus converts vertical pressure into radial pressure on the annulus fibrosus, and disc load is linked to the weight of the body above it. The intensity of this load increases as one moves down the spine, particularly at L4-L5 and L5-S1 (Thapa et al., 2016).

In our study, disc bulging was the most prevalent form of displacement, occurring in 43 out of 57 patients, followed by disc protrusion in 25 patients and disc extrusion in 5 patients (Thapa et al., 2016). Our observations are consistent with these findings, as the most common displacement was disc bulging (59.2%), followed by disc protrusion (35.9%) and disc extrusion (4.8%). Disc protrusion was most notable at the L4-L5 level, likely because this level serves as the transition point for coupled rotation and flexion, making it subject to greater stress than other lumbar levels.

Statistically significant associations were found at the lower lumbar levels. At L4-L5, a correlation was established between desiccation and disc bulging ($p = 0.035$) and between desiccation and disc protrusion ($p = 0.046$). Similarly, at L5-S1, there was a significant association between desiccation and disc bulging ($p = 0.025$) and between desiccation and disc protrusion ($p = 0.046$).

Beyond mechanical factors, genetic predisposition, lifestyle, and metabolic factors also play significant roles in disc degeneration. Kalichman et al. (2007) highlighted the heritability and familial predisposition in disc degeneration, suggesting that genetic determinants require further attention in developing targeted interventions.

Limitations of the Study

This study had certain limitations, including a small sample size due to the high cost and limited accessibility of MRI. Further research with larger cohorts or prospective designs is needed. Additionally, there is no universally accepted reference for staging IDD, particularly in biochemical and histological assessments. Although the Pfirrmann grading system demonstrated excellent concordance, it provides only a morphological and semi-quantitative evaluation of IDD.

Furthermore, the single-center nature of our study limits the generalizability of the findings to the entire Kinshasa province. The cross-sectional design also prevents the establishment of causal relationships.

Merit of the Study

This study provides significant insights into the progression of lumbar disc herniation in the context of lumbar disc desiccation, specifically within the Democratic Republic of the Congo. It highlights its impact on the adult population and underscores the need for management strategies tailored to this unique context.

CONCLUSIONS

IDD is central to degenerative disc diseases and can affect all spinal disc levels. Our findings indicate an increased prevalence of lumbar disc degeneration in individuals over 50 years of age, affecting up to 66.7% of people in this age group. Among disc displacements, disc bulging was the most common, occurring in 59.2% of cases.

Magnetic resonance imaging remains the modality of choice for accurately assessing disc desiccation. Based on the collected data, several key findings emerge:

- The significant impact of IDD on middle-aged and elderly adults, particularly those of working age, affecting their economic contributions.
- The variability in intervertebral disc desiccation types, reflecting the complexity of degenerative disc disease in our setting.
- The necessity for an individualized approach in patient management due to the diverse clinical presentations.

Authors' Contributions:

i. **Study conception and design**: DMI, FTT, and JTM.
ii. **Data acquisition**: OZN, STY, PK, LM, and GN.
iii. **Manuscript writing**: DMI and JKK.
iv. **Data analysis and interpretation**: STY and JKK.
v. **Final revision and approval of the manuscript**: JTM and MTL.

Data Availability: Due to the nature of participants' consent, anonymized data may be made available to investigators upon reasonable request to the corresponding author.

Acknowledgement: We would like to thank all those who supported us in data collection and manuscript preparation, particularly the physicians at Diamant Hospital, who willingly approved and supervised the data collection for this study.

Ethical Approval: This study was reviewed and approved by the Ethics Committee of the School of Public Health of the University of Kinshasa, acting as the National Ethics Committee (Approval number: ESP/CE/079/2023). Confidentiality and ethical standards were upheld in accordance with the Helsinki Declaration (1964).

Conflicts of Interest: None declared.

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