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Research Article

Frontal Pneumosinus Dilatans: A Rare Partner of Panpolyposis

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Abstract: *Introduction:* Pneumosinus dilatans (PSD) is a rare condition characterized by abnormal expansion of one or more paranasal sinuses beyond normal anatomical limits, with intact sinus walls. This study aims to highlight Frontal PSD linked with chronic rhinosinusitis and sinonasal polyposis, emphasizing the diagnostic and therapeutic challenges involved. **Methodology:** In a combined prospective and retrospective study spanning over 30 years, 11 cases of isolated frontal PSD were identified. CT imaging of paranasal sinuses was used for diagnosis. Five symptomatic patients aged 16–30 years showed features including frontal bossing, hypertelorism, and anosmia. These individuals underwent medical management with oral steroids followed by functional endoscopic sinus surgery (FESS). Asymptomatic patients were managed conservatively. **Results:** Among the 11 patients (9 males, 2 females), 5 presented with associated sinonasal polyposis on imaging. Post-operative outcomes were assessed via clinical follow-up, CT scans, and nasal endoscopy at 6 weeks and 6 months. Significant symptomatic improvement and reversal of facial deformities were observed, likely due to bone remodeling. No cosmetic surgical intervention was required, and no recurrence of disease was noted on follow-up. **Conclusion:** Though rare and often asymptomatic, PSD can coexist with sinonasal disease, leading to both functional and cosmetic concerns. FESS offers a safe, effective approach for managing symptomatic cases, with potential for reversing associated facial dysmorphia and preventing further sinus expansion.

Keywords: Bone remodeling, FESS, Frontal Sinus, Pneumosinus dilatans, Polyposis

INTRODUCTION

Pneumosinus dilatans (PSD), defined as the expansion of a paranasal sinus beyond its normal anatomical limits with preserved bony walls, is a rare condition with less than 200 cases reported till date. Although first described by Meyes in 1898 as a “pneumocele”, it was Benjamin in 1918 who formally coined the term “pneumosinus dilatans” to distinguish it from pneumatocele[1]. It can affect single or multiple sinuses, with the frontal sinus being the most commonly involved, followed by the sphenoid, maxillary, and ethmoid sinuses [2]. In rare instances, PSD can involve multiple paranasal sinuses along with the mastoid air cells, a condition termed pneumosinus dilatans multiplex.

Despite its generally benign and asymptomatic course, PSD may present with aesthetic deformities, neurological disturbances, or ophthalmologic complications. Various theories have been proposed regarding its etiology, including the one-way valve mechanism, congenital defects, hormonal influences, and associations with neoplastic conditions such as meningiomas and arachnoid cysts [3]. Most cases are incidental radiological findings, rarely associated with chronic sinonasal pathology. We retrospectively analysed 11 cases of isolated frontal sinus PSD, associated with sino-nasal pathology over a period of 30 years at a tertiary care hospital.

Methodology:

This was a prospective–cum–retrospective observational study conducted at a tertiary care referral centre over a 30-year period (January 1994 to December 2024). The study evaluated the clinical presentation, radiological features, management

strategies, and outcomes of patients with frontal pneumosinus dilatans (PSD). A total of 11 patients with radiologically confirmed frontal pneumosinus dilatans were identified during the study period.

Inclusion criteria

- Radiological diagnosis of frontal pneumosinus dilatans on CT-PNS
- Presence of sinonasal symptoms such as nasal obstruction, headache, anosmia, or facial deformity
- Patients undergoing surgical intervention with available follow-up data

Exclusion criteria

- Asymptomatic patients with incidentally detected frontal PSD
- Frontal sinus enlargement secondary to trauma, neoplasms, or prior sinus surgery
- Incomplete clinical or radiological records

CLINICAL EVALUATION: All symptomatic patients underwent a detailed clinical evaluation, including assessment of sinonasal symptoms, duration of complaints, and craniofacial features such as frontal bossing, hypertelorism, and nasal bridge widening (Figure 1). Anterior rhinoscopy and diagnostic nasal endoscopy (DNE) were performed in all cases.

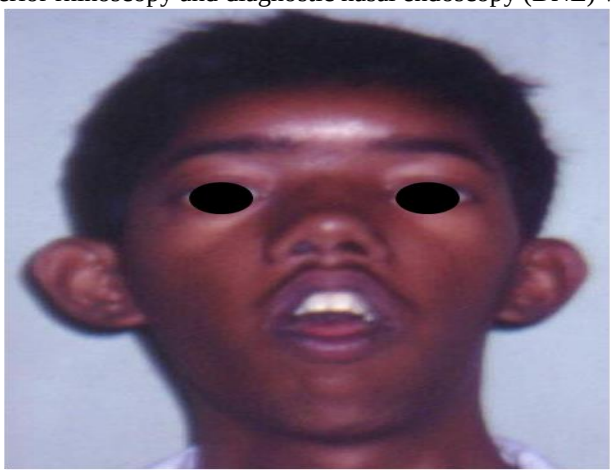

Figure 1. Clinical picture 17 year old male with bilateral nasal obstruction. Physical examination showing nasal bridge widening, hypertelorism, frontal bossing along with high arched palate and crowding of teeth

RADIOLOGICAL EVALUATION (Figure 2): All patients underwent computed tomography of the paranasal sinuses (CT-PNS) in axial and coronal planes. Frontal pneumosinus dilatans was diagnosed based on:

- Abnormal enlargement of the frontal sinus beyond normal anatomical limits
- Intact sinus walls without evidence of bony erosion
- Expansion with or without intracranial extension

Associated sinonasal pathologies such as chronic rhinosinusitis, pan-polyposis, deviated nasal septum, concha bullosa, and fungal sinus disease were documented (Figure 3).

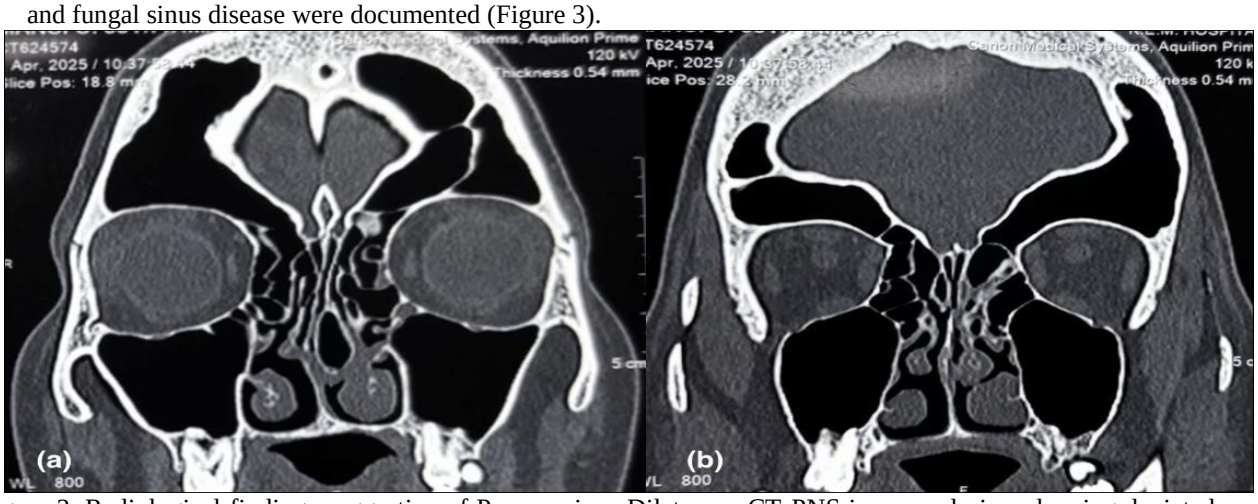

Figure 2. Radiological findings suggestive of Pneumosinus Dilatans . CT-PNS in coronal view showing deviated nasal septum (DNS) to right with left concha bullosa, left inferior turbinate hypertrophy (a) and abnormally enlarged bilateral frontal sinus showing the typical "deer-horn" appearance of frontal pneumosinus dilatans (PSD)(b).

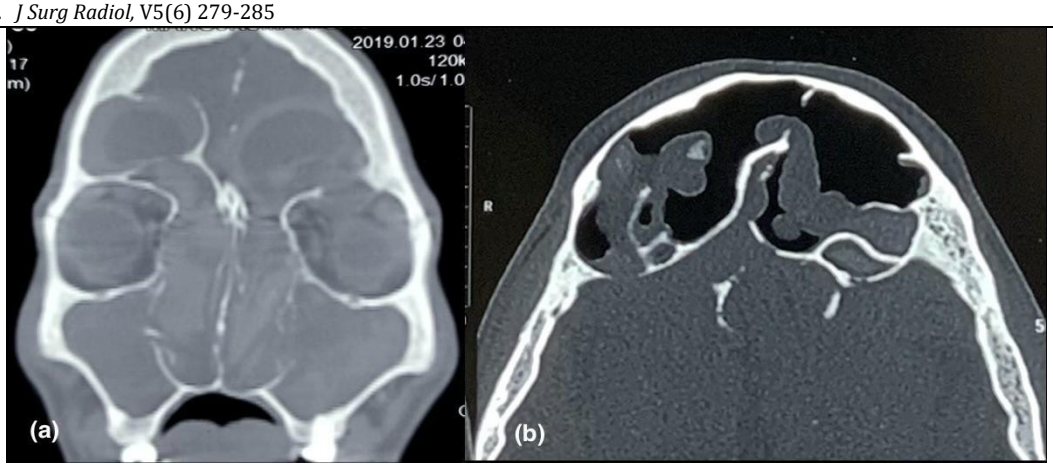

Fig. 3. Computed tomography of paranasal sinuses (CT-PNS) coronal section showing extensive bilateral sinonasal polyposis (a) with abnormally large frontal sinus bulging into intracranial compartment. Axial view of CT-PNS in the same patient showing absent interfrontal septum, large frontal sinus & polyps (b).

Preoperative Medical Management

All symptomatic patients received a short course of oral corticosteroids (methylprednisolone) prior to surgery, with the dosage tapered over approximately two weeks, to reduce mucosal inflammation and polyp burden.

Surgical Management

Surgical intervention was tailored according to clinical and radiological findings. Functional endoscopic sinus surgery (FESS) was the primary surgical approach and was performed under general anesthesia using rigid nasal endoscopes (0° and angled scopes).

The procedure involved:

- Endoscopic removal of nasal polyps using forceps and microdebrider
- Uncinectomy and widening of sinus ostia
- Clearance of maxillary, ethmoid, sphenoid, and frontal sinuses
- Identification and clearance of the frontal recess using angled instruments (Figure 4).

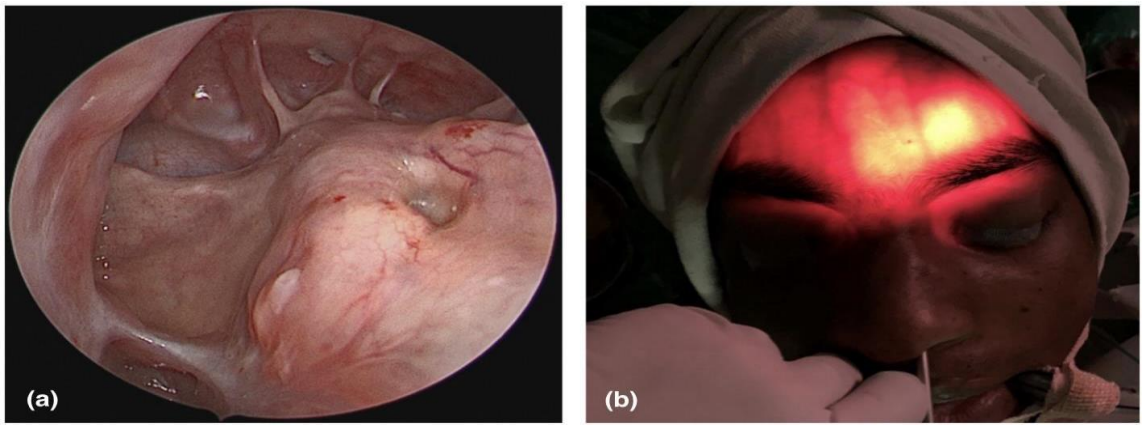

Fig.4. (a) Intraoperative endoscopic view of frontal sinus showing abnormally large sinus with absent interfrontal septum. (b) Intraoperative picture of the same patient showing “the frontal glow” after polyp clearance and adequate frontal ostium widening.

In cases where disease involved the lateral aspect of the frontal sinus and was inaccessible endoscopically, a combined endoscopic and limited external approach using a frontal trephine via a medial brow incision was employed. Additional procedures such as septoplasty, conchoplasty, or inferior turbinoplasty were performed when indicated.

Postoperative Care and Follow-up

Postoperatively, patients received oral antibiotics and saline/alkaline nasal douching. Follow-up assessments were conducted at 6 weeks, 3 months, and 6 months (Figure 5), with serial diagnostic nasal endoscopy to evaluate healing, sinus patency, and recurrence.

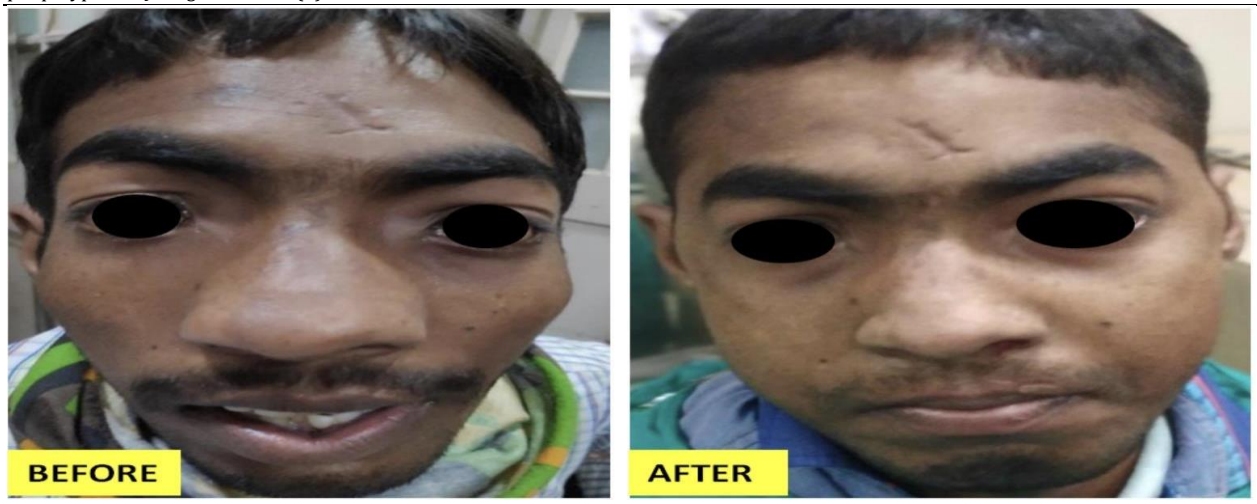

Figure 5: 21 year old male with bilateral nasal obstruction and nasal bridge widening with hypertelorism. The same patient on 3 months post FESS surgery follow up visit showed marked improvement in facial aesthetics.

Outcome Measures

Primary outcome measures included:

- Resolution of sinonasal symptoms
- Endoscopic evidence of disease clearance
- Postoperative complications
- Recurrenceduringfollow-up

Ethical Considerations

The study was approved by the Institutional Ethics Committee letter number IEC(III)/OUT/43/2024 dated 15th January 2024. Written informed consent was obtained from all patients. Patient confidentiality was maintained, and the study adhered to ethical standards and the principles of the Declaration of Helsinki.

RESULTS

A total of 11 patients were identified with radiological features of frontal pneumosinus dilatans during the study period. Among these, 5 patients (45.4%) were symptomatic and constituted the study population. The remaining 6 patients (54.6%) were asymptomatic, with frontal PSD detected incidentally on imaging.

All symptomatic patients were young adults, with ages ranging from 17 to 30 years. There was a male predominance, with 4 males and 1 female among the symptomatic group.

All symptomatic patients presented with nasal obstruction (100%). Other associated symptoms included headache in 3 patients (60%), anosmia in 1 patient (20%) and recurrent rhinitis in 1 patient (20%)
Craniofacial abnormalities were noted in several patients, including frontal bossing in 2 patients , nasal bridge widening in 2 patients , and hypertelorism in 2 patients. One patient also exhibited dental crowding and a high-arched palate.

Diagnostic nasal endoscopy revealed bilateral nasal polyposis in 4 patients (80%) and unilateral nasal pathology in 1 patient (20%).
CT-PNS confirmed marked enlargement of the frontal sinuses with intact bony walls in all cases. Radiological findings among symptomatic patients included the presence of Frontal PSD with sinonasal pan-polyposis and chronic rhinosinusitis in 4 patients. Isolated frontal pneumosinus dilatans in 1 patient. Intracranial extension of the enlarged frontal sinus was observed in 2 patients, without evidence of bony erosion or intracranial complications. One patient demonstrated compression over the frontal lobe without neurological deficit. Associated sinonasal findings included chronic rhinosinusitis, deviated nasal septum, concha bullosa, inferior turbinate hypertrophy, and fungal sinus disease.

Surgical Management

All symptomatic patients underwent functional endoscopic sinus surgery (FESS) following a short course of preoperative oral corticosteroids. Pure endoscopic FESS was sufficient in 4 patients (80%). Combined endoscopic and limited external approach using frontal trephination was required in 1 patient (20%) due to disease involving the lateral aspect of the frontal sinus which was inaccessible endoscopically. Additional procedures such as septoplasty, conchoplasty, and inferior turbinoplasty were performed when indicated.
Intraoperatively, an abnormally large frontal sinus cavity was observed in all cases, with absence of the interfrontal septum in one patient. A prominent “frontal glow”

following frontal sinus clearance was noted in multiple cases.

All the patients had an uneventful postoperative course. There were no intraoperative or postoperative complications.

At follow-up, complete resolution of nasal obstruction was achieved in all patients. Headache and associated sinonasal symptoms resolved in all affected patients. Serial diagnostic nasal endoscopies at 6 weeks, 3 months, and 6 months showed well-healed cavities with no evidence of residual or recurrent disease. No recurrence of symptoms or disease was noted during the follow-up period.

Asymptomatic Patients

The remaining 6 asymptomatic patients demonstrated typical radiological features of frontal pneumosinus dilatans, including marked frontal sinus enlargement with intact walls and a characteristic "deer-horn" appearance on CT-PNS. These patients required no surgical intervention and were managed conservatively.

DISCUSSION

Pneumosinus dilatans (PSD) remains an enigmatic condition with an unclear pathophysiological basis. It is a rare disorder involving the abnormal expansion of one or more paranasal sinuses beyond their normal anatomical limits, without evidence of bony destruction. Urken et al. categorized paranasal sinus expansion into hypersinus, pneumosinus dilatans, and pneumocele, based on radiological enlargement and clinical symptoms [1]. Hypersinus represents an enlarged sinus but within normal anatomical limits, PSD denotes sinus expansion beyond normal limits with preserved bony walls, while pneumocele involves sinus expansion with thinning or erosion of the bony walls.

PSD most frequently affects the frontal sinus, followed by the sphenoid,maxillary, and ethmoid sinuses [2]. In our series, we came across isolated frontal pneumosinus dilatans only.

The precise etiology of PSD remains controversial, with multiple theories proposed over the years. The most widely accepted mechanism is the one-way valve hypothesis, which suggests that an obstruction in the sinus ostium leads to air trapping, causing progressive sinus expansion due to unidirectional airflow [3]. This theory aligns with clinical findings of sinus ostium obstruction in our cases of PSD. Other proposed mechanisms include hormonal influences, particularly osteoblastic and osteoclastic activity variations, which may contribute to abnormal sinus expansion. Some studies have suggested a link between PSD and conditions such as acromegaly, where excessive growth hormone may influence sinus pneumatization [4]. Additionally, congenital anomalies, such as embryological defects leading to excessive pneumatization of the sinuses, have been considered as a causative factor [5]. Another hypothesis involves spontaneous rupture of mucoceles, where the mucoceles itself causes gradual sinus expansion and its spontaneous drainage can lead to PSD [6]. There have also been discussions about infection with gas-forming microorganisms, which could theoretically produce excessive gas within the sinus cavity, leading to its expansion. However, no definitive infectious agents have been identified in PSD cases.

PSD is frequently asymptomatic and diagnosed incidentally during imaging studies. However, symptomatic cases may present with a range of manifestations depending on the affected sinus. Frontal sinus involvement often leads to frontal bossing, a cosmetic concern that results from progressive expansion of the sinus wall anteriorly [6]. Other common symptoms include headache, facial pain or paraeshthesia, and nasal obstruction, particularly in cases associated with chronic rhino-sinusitis or nasal polyposis. Patients in our case series also exhibited similar symptoms like frontal bossing, headache, nasal obstruction. In cases where PSD affects the sphenoid or ethmoid sinuses, ophthalmologic symptoms such as proptosis, diplopia, or compressive optic neuropathy causing visual impairment may occur due to the proximity of these sinuses to the orbit and optic nerve [7]. Patients with PSD may also experience epiphora due to nasolacrimal duct compression or extensive polyposis can cause Eustachian tube dysfunction leading to serous otitis media causing decreased hearing and earache.

In a 2021 literature review, amongst the 171 patients of PSD described from 1918 to 2021, it has been mentioned that 69.5% were males and 31.5% of the patients were in the age group of 11-20 years [7]. These findings are consistent with our study which includes 9 males and 2 female patients in the range of 16-30 years of age, indicating male predominance and young adult age group of presentation.

Radiological assessment is the cornerstone of PSD diagnosis, with computed tomography of the paranasal sinuses (CT-PNS) being the gold standard. In 2017, Afroze et al. referred to the frontal PSD as the "Deer Horn Sinus" because, on coronal computed tomography (CT) images, the condition can resemble a deer horn [8]. The differentiation of PSD from similar conditions like hypersinus and pneumocele can be made on CT scan. Magnetic resonance imaging (MRI) is required in cases with suspected intracranial involvement, particularly if

there is an association with arachnoid cysts or meningiomas. The presence of a mass or bony erosion on imaging should raise suspicion for an alternative diagnosis such as fibrous dysplasia, osteoma, or other neoplastic conditions.

The management of PSD is largely dictated by the severity of symptoms. Asymptomatic cases require no intervention, although patients should be advised to avoid smoking and manage any underlying allergic rhino-sinusitiswith intranasal corticosteroids, antihistamines and periodic follow ups. However, in patients with polyposis or chronic rhino-sinusitis, functional endoscopic sinus surgery (FESS) is the preferred treatment modality.

FESS acts 3 folds in PSD with symptoms, firstly by relieving sino-nasal symptoms while preserving sinus function, secondly adequately widened sinus ostium impairs the one way valve hence prevents further sinus expansion. Finally, post FESS we observed improved facial aesthetics as reversal of pathology allowed bone remodelling. In cases where significant bone deformity is present, a combined endoscopic and external surgical approach may be necessary [9]. Preoperative corticosteroid therapy is often employed to reduce mucosal inflammation, improve surgical field, and minimize intraoperative bleeding.

Cosmetic concerns related to frontal bossing may warrant surgical correction, although our cases demonstrated postoperative facial remodeling following FESS. This suggests that addressing the underlying sinus pathology allows for gradual bone adaptation and resolution of deformities. In cases where cosmetic deformity persists, reconstructive procedures with open approaches like osteoplastic flap surgery have been described in literature [10]. Several open surgical techniques have been documented to address the frontal deformity, including the craniofacial approach with alloplastic materials, anterior table reduction of the frontal sinus without replacement, and anterior table excision with subsequent reconstruction using autologous bone secured with mini plates or a titanium mesh plate [9, 10].

Patients with PSD have a favorable prognosis following appropriate intervention. Long-term follow-up is recommended, particularly in cases with extensive sinus involvement or those associated with intracranial pathology.

CONCLUSION

Pneumosinus dilatans represents a rare but significant entity characterized by the expansion of paranasal sinuses beyond normal anatomical limits, with CT imaging essential for differentiation from hypersinus and pneumocele. Most cases remain asymptomatic, with gradual changes in facial contour being the predominant clinical feature. Although PSD is seldom associated with sinonasal pathology, our study underscores its rare coexistence with panpolyposis and chronic rhinosinusitis, necessitating surgical intervention.The primary objective of treatment remains symptom relief and prevention of further sinus expansion, with FESS being the standard surgical approach. None of our patients required cosmetic intervention, as postoperative bone remodeling led to satisfactory facial contouring. Early identification and management of symptomatic PSD can prevent complications and improve long-term outcomes.

Declarations

- Ethics approval and consent to participate: Yes
- Consent for publication: Yes
- Availability of data and material: Yes
- Competing interests: None
- Funding: None
- Acknowledgements: none

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