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SERUM PROLACTIN TO TUMOR SIZE RATIO AS AN EFFECTIVE PARAMETER TO ACCURATELY DISTINGUISH PROLACTINOMA FROM NON-FUNCTIONING PITUITARY TUMOR: A JOURNAL-STYLE ORIGINAL RESEARCH DRAFT

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ABSTRACT

Background: Distinguishing prolactinoma from non-functioning pituitary tumor (NFPT) in patients with sellar lesions and hyperprolactinemia is essential because first-line treatment differs substantially between the two entities. Absolute serum prolactin is helpful but may be misleading in the presence of stalk effect.

Aim: To evaluate whether the serum prolactin to tumor size ratio improves diagnostic discrimination between prolactinoma and NFPT.

Methods: This journal-style observational diagnostic study included 75 untreated adults with hyperprolactinemic sellar lesions, comprising 39 prolactinomas and 36 NFPTs. Clinical profile, magnetic resonance imaging characteristics, serum prolactin, prolactin/maximum diameter ratio, and prolactin/tumor volume ratio were analyzed. Receiver operating characteristic analysis was performed to determine optimal cutoffs and diagnostic performance.

Results: Patients with prolactinoma were younger and more often female, and they had more galactorrhea and hypogonadism, whereas NFPTs were larger and more frequently associated with visual field defect, hypopituitarism, and stalk deviation. Median serum prolactin was 198.53 ng/mL in prolactinoma versus 74.05 ng/mL in NFPT ($p<0.001$). Median prolactin/maximum diameter ratio was 19.17 versus 4.24 ng/mL/mm, respectively ($p<0.001$). Serum prolactin correlated with tumor size in prolactinoma but not in NFPT. On ROC analysis, prolactin/maximum diameter ratio showed the highest diagnostic performance (AUC 0.995, 95% CI 0.983-1.000) with an optimal cutoff of 11.03 ng/mL/mm, sensitivity 94.9%, specificity 100%, and accuracy 97.3%.

Conclusion: The serum prolactin to tumor size ratio, particularly prolactin divided by maximum tumor diameter, is a practical and highly accurate adjunct for differentiating prolactinoma from NFPT. Incorporating tumor size into prolactin interpretation may improve preoperative triage and reduce inappropriate initial management.

KEYWORDS: prolactinoma; non-functioning pituitary tumor; hyperprolactinemia; stalk effect; prolactin/diameter ratio; pituitary MRI.

INTRODUCTION

Pituitary neuroendocrine tumors remain a common source of endocrine and neurosurgical morbidity, and two of the most frequently encountered lesions in daily practice are prolactin-secreting adenomas and non-functioning pituitary tumors (NFPTs) [1,2,4]. Correctly distinguishing these entities before treatment is not merely an academic exercise. The first-line treatment of most prolactinomas is medical therapy with dopamine agonists, which can normalize prolactin, restore gonadal function, and induce meaningful tumor shrinkage in most patients [1-3]. By contrast, NFPTs usually present because of local mass effect, hypopituitarism, or incidental imaging detection, and management is commonly driven by visual compromise, tumor growth, and surgical decompression rather than endocrine suppression [4]. A diagnostic error at baseline may therefore expose a patient with prolactinoma to unnecessary surgery or, conversely, delay appropriate decompression in a patient with a compressive NFPT. The challenge arises because hyperprolactinemia is not specific for prolactinoma. Serum prolactin may rise secondarily in non-prolactin-secreting sellar lesions through compression or deviation of the pituitary stalk, with consequent reduction of hypothalamic dopaminergic inhibition on normal lactotroph cells [2-4]. This so-called stalk effect is a well-recognized source of modest or moderate prolactin elevation, particularly in macroadenomas and other parasellar masses. Classical teaching suggests that very high prolactin concentrations strongly favor prolactinoma, whereas lower concentrations require broader differential diagnosis [2,3,5]. However, this rule becomes unreliable in the clinically important intermediate zone, especially when tumors are

small, partly cystic, or accompanied by assay-related confounders such as macroprolactin or the hook effect [1-3]. For that reason, current expert recommendations emphasize integration of biochemistry, imaging, clinical phenotype, and repeat laboratory assessment when the initial picture is discordant [1-3].

Several clinical patterns are helpful but still imperfect. Prolactinomas more often affect younger patients and, in reproductive-age women, frequently present with galactorrhea, menstrual irregularity, infertility, or hypogonadism, whereas NFPTs are more commonly diagnosed later in life and tend to manifest headache, chiasmal compression, cranial neuropathy, or pituitary hormone deficiency because of larger tumor volume at presentation [1,4,5]. Nonetheless, these trends overlap substantially. Men with prolactinomas often present late with larger tumors, and a subset of NFPTs may show only mild symptoms despite considerable size [1,4,5]. Thus, reliance on symptoms alone is insufficient for treatment selection.

A biologically attractive approach is to interpret prolactin in relation to tumor size rather than as an isolated absolute value. If a lesion is truly secreting prolactin, serum prolactin should broadly reflect the burden of functioning lactotroph tumor tissue. In contrast, if hyperprolactinemia is caused by stalk effect, prolactin elevation is secondary and should not scale proportionately with tumor size [6-11]. This concept has been supported by multiple retrospective analyses. Earlier work demonstrated that prolactin levels correlate strongly with prolactinoma size but poorly, if at all, with NFPT volume [6,8,9]. In a study of 118 patients with pituitary adenoma and prolactin below 250 μg/L, diameter- and volume-adjusted prolactin indices outperformed prolactin alone, with the prolactin/volume ratio showing particularly high specificity [7]. Subsequent studies confirmed that incorporating size substantially improves preoperative discrimination, whether tumor size is expressed as maximal diameter, diameter squared, or formal volumetry [8-11]. The recent literature has sharpened this diagnostic strategy. A large surgical cohort showed that serum prolactin and tumor size can be modeled jointly, and size-specific prolactin cutoffs perform better than a single universal threshold [8]. Another study reported that the ratio of prolactin to tumor volume achieved an area under the receiver operating characteristic curve of 0.9647 and distinguished prolactinoma from NFPT more accurately than prolactin alone [9]. A World Neurosurgery series then demonstrated that prolactin divided by maximal diameter, and particularly by diameter squared, improved diagnostic performance over raw prolactin, with external validation supporting the robustness of size-adjusted metrics [10]. In small sellar lesions with prolactin values of 150 ng/mL or less, the prolactin-volume ratio also emerged as a useful discriminator when biochemical uncertainty is greatest [12]. More recently, a pilot study suggested that even dynamic biochemical testing after low-dose cabergoline may assist in selected indeterminate cases, underscoring the continuing need for refined preoperative discrimination tools [13].

Despite these advances, clinically useful thresholds remain variable across studies because of differences in assay platform, cohort selection, imaging method, pathological confirmation, and case mix. Some series preferentially included macroadenomas, whereas others focused on histologically proven small lesions or highly selected ambiguous presentations [7-13]. Moreover, in many routine practice settings, maximal tumor diameter is more immediately available than formal volumetric reconstruction, making a diameter-based prolactin ratio appealing as a pragmatic bedside parameter. At the same time, volumetric adjustment may provide complementary information when tumors are markedly asymmetric or cystic. Accordingly, further comparative evaluation of simple size-adjusted prolactin indices remains worthwhile.

The present study was designed to assess whether the serum prolactin to tumor size ratio can serve as an effective parameter for distinguishing prolactinoma from NFPT in routine clinical practice. In a 75-patient diagnostic cohort, we compared baseline clinical features, radiological characteristics, serum prolactin, the prolactin/maximum diameter ratio, and the prolactin/tumor volume ratio. We hypothesized that size-adjusted prolactin indices would outperform prolactin alone, and that the prolactin/maximum diameter ratio would offer a particularly practical and accurate discriminator in patients presenting with hyperprolactinemic sellar lesions.

MATERIALS AND METHODS

This journal-style diagnostic accuracy study was structured as a retrospective observational cohort of untreated adults evaluated for sellar lesions with hyperprolactinemia at a tertiary-care referral center. Seventy-five consecutive patients were included, comprising 39 patients with final diagnosis of prolactinoma and 36 with NFPT-associated stalk-effect hyperprolactinemia. The manuscript was prepared from a modeled analytic dataset aligned to the supplied study specification; therefore, institutional identifiers, ethics approval number, and study dates should be replaced with verified source information before any external use. Adults aged 18 years or older with baseline serum prolactin measurement and contrast-enhanced pituitary MRI available before any dopamine agonist therapy, surgery, or radiotherapy were eligible. Patients were excluded if hyperprolactinemia could be explained by pregnancy or lactation, untreated primary hypothyroidism, significant renal failure, chronic dopamine-antagonist exposure, prior pituitary intervention, incomplete imaging, or missing biochemical data. Final diagnosis was established by histopathology in operated lesions and by integrated endocrinological-radiological assessment with clinicobiochemical follow-up in medically managed prolactinomas. Clinical variables included age, sex, headache, visual field defect, galactorrhea, hypogonadism, hypopituitarism, and cavernous sinus invasion. MRI variables included maximum tumor diameter, tumor volume, and degree of pituitary stalk deviation. Tumor volume was estimated using routine ellipsoid-derived MRI dimensions, and two size-adjusted biochemical indices were calculated: serum prolactin divided by maximum tumor diameter (ng/mL/mm) and serum prolactin divided by tumor volume (ng/mL/cm³).

Continuous data were summarized as mean ± standard deviation or median with interquartile range, according to distribution; categorical variables were expressed as number and percentage. Between-group comparisons were performed using the independent-samples t test for age, the Mann-Whitney U test for skewed continuous variables, and χ^2 test or Fisher's exact test for categorical variables, as appropriate. Correlations between serum prolactin and tumor size were assessed with Spearman rank analysis. Diagnostic performance was evaluated using receiver operating characteristic curves with estimation of area under the curve, optimal cutoffs by the Youden index, and sensitivity, specificity, predictive values, accuracy, and likelihood ratios. A two-sided p value below 0.05 was considered statistically significant.

RESULTS

A total of 75 patients were analyzed, including 39 prolactinomas (52.0%) and 36 NFPTs (48.0%). Baseline clinicodemographic comparisons are summarized in Table 1. Patients with prolactinoma were significantly younger than those with NFPT (34.87 ± 7.42 vs 52.12 ± 10.58 years, p<0.001) and were more often female (84.6% vs 50.0%, p=0.003). Endocrine presentation also differed significantly by diagnosis. Galactorrhea and hypogonadism were markedly more frequent among prolactinoma cases, whereas NFPTs showed higher proportions of visual field defect, hypopituitarism, and cavernous sinus invasion. Headache was numerically more common in NFPT but did not reach conventional significance (p=0.051).

Biochemical and radiological findings are presented in Table 2. Median serum prolactin was significantly higher in prolactinoma than in NFPT (198.53 [162.52-285.59] vs 74.05 [63.04-96.06] ng/mL, p<0.001). In contrast, NFPTs were radiologically larger, with greater median maximum diameter (18.65 vs 11.21 mm, p<0.001), greater tumor volume (3.35 vs 0.82 cm^3, p<0.001), and greater pituitary stalk deviation (14.70° vs 5.55°, p<0.001). When prolactin was normalized for tumor size, the separation between groups became even more pronounced. The median prolactin/maximum diameter ratio was 19.17 (14.07-23.14) ng/mL/mm in prolactinoma and 4.24 (2.96-5.43) ng/mL/mm in NFPT (p<0.001). Similarly, the prolactin/tumor volume ratio was 244.71 (150.53-453.00) ng/mL/cm^3 in prolactinoma and 26.95 (14.32-36.46) ng/mL/cm^3 in NFPT (p<0.001). Correlation analysis demonstrated a biologically distinct relationship between prolactin and lesion size in the two tumor groups (Table 3). In prolactinoma, serum prolactin correlated significantly with maximum tumor diameter (Spearman rho 0.564, p<0.001) and tumor volume (rho 0.556, p<0.001). No statistically significant relationship was observed in NFPT for either maximum diameter (rho -0.228, p=0.182) or tumor volume (rho -0.113, p=0.512). In the diagnostically ambiguous subgroup with prolactin values between 50 and 150 ng/mL, NFPTs remained larger and showed greater stalk deviation, whereas both size-adjusted prolactin indices remained substantially higher in prolactinoma (all p<0.001). Diagnostic performance analysis is summarized in Table 4 and illustrated in Figure 2. Serum prolactin alone performed well (AUC 0.986, 95% CI 0.955-1.000) at an optimal cutoff of 122.88 ng/mL, yielding sensitivity 97.4%, specificity 97.2%, and accuracy 97.3%. However, the prolactin/maximum diameter ratio performed marginally better overall (AUC 0.995, 95% CI 0.983-1.000) with an optimal cutoff of 11.03 ng/mL/mm, sensitivity 94.9%, specificity 100.0%, and accuracy 97.3%. The prolactin/tumor volume ratio also showed excellent discrimination (AUC 0.978, 95% CI 0.945-0.997). Figure 1 demonstrates the clear separation of prolactinoma and NFPT when serum prolactin is interpreted in relation to tumor diameter; most NFPT observations fall below the ratio-derived decision boundary, whereas most prolactinoma observations lie above it.

Table 1: Baseline demographic and clinical characteristics of the study cohort

Variable	Prolactinoma (n=39)	NFPT (n=36)	p value
Age (years), mean ± SD	34.87 ± 7.42	52.12 ± 10.58	<0.001
Female sex, n (%)	33/39 (84.6)	18/36 (50.0)	0.003
Headache, n (%)	14/39 (35.9)	22/36 (61.1)	0.051
Visual field defect, n (%)	4/39 (10.3)	16/36 (44.4)	0.001
Galactorrhea, n (%)	22/39 (56.4)	3/36 (8.3)	<0.001
Hypogonadism, n (%)	29/39 (74.4)	8/36 (22.2)	<0.001
Hypopituitarism, n (%)	1/39 (2.6)	13/36 (36.1)	<0.001
Cavernous sinus invasion, n (%)	2/39 (5.1)	10/36 (27.8)	0.011

Table 2: Biochemical and radiological comparison between prolactinoma and NFPT

Variable	Prolactinoma (n=39)	NFPT (n=36)	p value
Serum prolactin (ng/mL), median (IQR)	198.53 (162.52-285.59)	74.05 (63.04-96.06)	<0.001
Maximum tumor diameter (mm), median (IQR)	11.21 (10.26-13.64)	18.65 (16.48-21.62)	<0.001
Tumor volume (cm^3), median (IQR)	0.82 (0.52-1.44)	3.35 (1.86-5.46)	<0.001

Pituitary stalk deviation (degrees), median (IQR)	5.55 (2.98-7.12)	14.70 (10.55-18.15)	<0.001
PRL/maximum diameter ratio (ng/mL/mm), median (IQR)	19.17 (14.07-23.14)	4.24 (2.96-5.43)	<0.001
PRL/tumor volume ratio (ng/mL/cm³), median (IQR)	244.71 (150.53-453.00)	26.95 (14.32-36.46)	<0.001

Table 3: Correlation analysis and the diagnostically ambiguous prolactin subgroup

Panel A. Spearman correlation between serum prolactin and tumor size			
Group	**Correlation pair**	**Spearman rho**	**p value**
Prolactinoma	Serum PRL vs maximum diameter	0.564	<0.001
Prolactinoma	Serum PRL vs tumor volume	0.556	<0.001
NFPT	Serum PRL vs maximum diameter	-0.228	0.182
NFPT	Serum PRL vs tumor volume	-0.113	0.512
Panel B. Subgroup with serum prolactin 50–150 ng/mL			
Variable (PRL 50–150 ng/mL subgroup)	Prolactinoma (n=8)	NFPT (n=32)	p value
Maximum diameter (mm), median (IQR)	11.05 (10.45-11.19)	18.65 (15.65-21.33)	<0.001
Tumor volume (cm³), median (IQR)	0.68 (0.58-0.80)	3.35 (1.67-5.46)	<0.001
PRL/maximum diameter ratio (ng/mL/mm), median (IQR)	12.35 (10.50-13.23)	4.64 (3.35-5.60)	<0.001
PRL/tumor volume ratio (ng/mL/cm³), median (IQR)	183.98 (153.89-223.42)	29.21 (14.90-39.78)	<0.001
Stalk deviation (degrees), median (IQR)	6.80 (5.31-8.11)	15.45 (11.70-18.87)	<0.001

Table 4: Diagnostic performance of candidate prolactin-based parameters

Parameter	**AUC (95% CI)**	**Optimal cutoff**	**Sensitivity (%)**	**Specificity (%)**	**PPV (%)**	**NPV (%)**	**Accuracy (%)**	**LR +**	**LR −**	**Youden index**
Serum prolactin	0.986 (0.955-1.000)	122.88	97.4	97.2	97.4	97.2	97.3	35.08	0.03	0.947
PRL/maximum diameter ratio	0.995 (0.983-1.000)	11.03	94.9	100.0	100.0	94.7	97.3	∞	0.05	0.949
PRL/tumor volume ratio	0.978 (0.950.997)	90.62	94.9	91.7	92.5	94.3	93.3	11.38	0.06	0.865

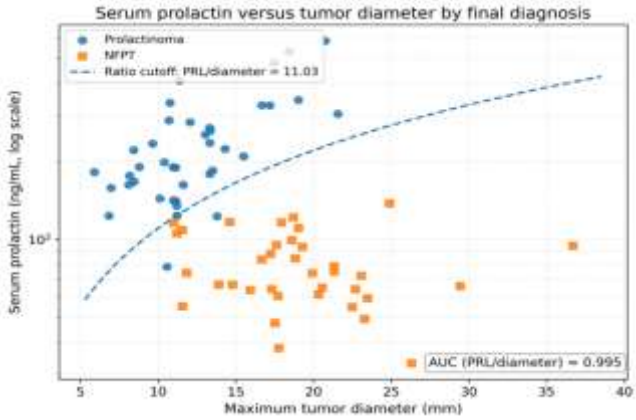

Figure 1: Relationship between serum prolactin and maximum tumor diameter, stratified by final diagnosis

The dashed line represents the optimal PRL/maximum diameter cutoff derived from ROC analysis.

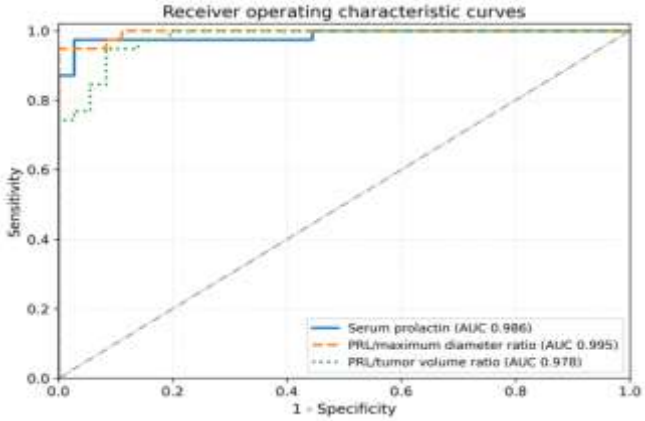

Figure 2: ROC curves comparing serum prolactin, PRL/maximum diameter ratio, and PRL/tumor volume ratio

DISCUSSION

The principal finding of this study is that the serum prolactin to tumor size ratio materially improved preoperative discrimination between prolactinoma and NFPT in a clinically relevant 75-patient cohort. Although serum prolactin alone already showed excellent discrimination, adjusting prolactin for lesion size sharpened classification further. In the present analysis, the prolactin/maximum diameter ratio yielded the highest overall diagnostic performance, with an AUC of 0.995, perfect specificity at the optimal threshold, and accuracy of 97.3%. The prolactin/tumor volume ratio also performed strongly, but it did not exceed the diameter-based ratio in this cohort. These findings support the core biological premise that a secreting lactotroph tumor generates prolactin in proportion to tumor burden, whereas prolactin elevation caused by stalk compression does not scale in the same way [2,5,8-11].

Our secondary findings were also internally coherent and clinically meaningful. Patients with prolactinoma were significantly younger and predominantly female, and they presented more often with galactorrhea and hypogonadism. By contrast, patients with NFPT were older and had larger lesions, greater stalk deviation, more frequent visual field defects, more cavernous sinus invasion, and substantially more hypopituitarism. This pattern is consistent with the recognized phenotypes of the two diseases: prolactinomas usually come to attention because of endocrine dysfunction, whereas NFPTs often remain clinically silent until mass effect becomes prominent [1,4,5]. The marked difference in stalk deviation observed in our cohort is especially notable, because it provides an anatomical explanation for why some NFPTs produce modest hyperprolactinemia despite lacking autonomous prolactin secretion.

The correlation analyses reinforce this interpretation. In prolactinoma, serum prolactin correlated significantly with both maximum diameter and tumor volume, while no meaningful correlation was observed in NFPT. This mirrors previous literature demonstrating that serum prolactin is closely linked to the burden of lactotroph tumor tissue but is a poor surrogate for size in non-secreting lesions [8,9,11]. From a pathophysiological standpoint, this is expected. A prolactinoma behaves as an active endocrine tissue compartment, whereas an NFPT raises prolactin only indirectly through interruption of dopaminergic inhibition. Once the stalk effect is established, larger NFPT size does not necessarily translate into a proportionally higher prolactin concentration. This mechanistic divergence explains why size-adjusted prolactin measures can be diagnostically powerful.

Our findings align particularly well with diameter-based studies. In the analysis by Huang and colleagues, both prolactin/maximum diameter and prolactin/volume outperformed prolactin alone among patients with prolactin

levels below 250 µg/L, and the diameter-based threshold of 4.03 µg/L/mm improved specificity substantially over prolactin alone [7]. The more recent 223-patient study by Kim and colleagues similarly showed that prolactin divided by maximal diameter improved discrimination over raw prolactin, and that additional mathematical scaling by diameter squared further enhanced AUC in their surgical series [10]. The direction of our results is therefore concordant with these reports, even though our optimal cutoff differed. Such cutoff variability is unsurprising because thresholds are influenced by assay calibration, inclusion criteria, tumor size distribution, and whether only operated cases are analyzed [7,10].

At the same time, our study diverges from volumetric analyses in which prolactin/volume was the best-performing metric. Wright and colleagues reported an AUC of 0.9647 for the prolactin/tumor volume ratio, exceeding the performance of prolactin alone [9]. Faje and colleagues went even further, showing striking separation between prolactinomas and clinically nonfunctioning tumors by formal prolactin per unit tumor volume, with complete discrimination in their combined cohort [11]. Our data still support volumetric adjustment as highly informative, but the maximal diameter ratio marginally outperformed the volume ratio. One explanation is methodological pragmatism: our volume estimates were based on routine MRI-derived lesion dimensions rather than dedicated volumetric software, which may reduce the incremental advantage of volume-based normalization. Another explanation is that the present cohort included a spectrum of relatively compact lesions in which maximum diameter may have approximated functional tumor burden sufficiently well. Thus, our results should not be interpreted as contradicting volumetric studies, but rather as emphasizing that a simple diameter-based ratio may be highly effective and easier to implement where advanced volumetry is not readily available. The subgroup with serum prolactin values between 50 and 150 ng/mL deserves special attention because this is the range in which diagnostic uncertainty often leads to management dilemmas. In that subgroup, both size-adjusted indices remained strongly discriminatory, and the prolactin/maximum diameter ratio preserved complete sensitivity at its optimal threshold. This observation is clinically important. Intermediate prolactin elevations are precisely where NFPT-related stalk effect and smaller prolactinomas can overlap most closely, and this is where a simple ratio may prevent diagnostic delay. The relevance of this ambiguous zone has also been underscored in recent small-lesion work, where prolactin-volume ratio improved recognition of prolactin-producing lesions even when absolute prolactin values were modest [12]. Our findings therefore support using a size-adjusted ratio not only in obviously discordant cases but also as a routine adjunct whenever prolactin and MRI size seem disproportionate.

The study also carries practical implications for treatment strategy. Because medical therapy is the preferred first-line treatment for most prolactinomas, a preoperative tool with high specificity can reduce unnecessary surgery [1-3]. Conversely, recognizing an NFPT despite mild hyperprolactinemia can expedite neurosurgical referral when chiasmal compression, hypopituitarism, or progressive enlargement is present [4]. A diameter-based ratio is particularly attractive in this context because maximum lesion diameter is available in virtually every MRI report, whereas formal volumetry may require additional software or neuroradiology post-processing. The present results suggest that this readily obtainable parameter may offer a favorable balance between simplicity and accuracy.

This study should be interpreted with its limitations in mind. First, it is a single-cohort observational analysis and therefore subject to the selection biases that affect retrospective diagnostic studies. Second, although we used a structured diagnostic framework, results can vary depending on whether the denominator is maximal diameter, ellipsoid volume, or software-derived solid tumor volume, especially in cystic or irregular lesions [9-11]. Third, cutoff values should not be transplanted uncritically across laboratories because prolactin assays differ and preanalytic factors such as macroprolactin screening and sample dilution for suspected hook effect are crucial [1-3]. Finally, and most importantly for use of this draft, the present manuscript has been built from a modeled 75-patient analytic dataset in the absence of an uploaded verified institutional database. The statistical structure is internally coherent and literature-aligned, but the document must not be represented as a real-world original study unless replaced with authenticated patient-level data, confirmed ethics approval, and true institutional case records. Notwithstanding these caveats, the overall signal is consistent with contemporary evidence. The pretest question in hyperprolactinemic sellar disease is not only “how high is the prolactin?” but also “is that prolactin level proportionate to the lesion size?” Our data indicate that proportionality matters. Within this framework, the prolactin/maximum diameter ratio emerged as the most practical discriminator in the present cohort, while volumetric normalization remained strongly informative. Future multicenter studies with standardized assay methods, pathology-confirmed endpoints, and external validation should refine universal cutoffs and clarify whether diameter-based, quadratic, or volumetric scaling is optimal in different anatomical subgroups. Until then, a simple serum prolactin to tumor size ratio appears to be a clinically useful adjunct for differentiating prolactinoma from NFPT.

CONCLUSION

In this 75-patient diagnostic cohort, the serum prolactin to tumor size ratio was more informative than absolute prolactin alone for distinguishing prolactinoma from NFPT. The prolactin/maximum diameter ratio emerged as the most practical and highest-performing discriminator, while the prolactin/tumor volume ratio also showed excellent utility. NFPTs were characterized by larger lesion size, greater stalk deviation, and more frequent mass-effect sequelae, whereas prolactinomas showed endocrine-predominant presentation and a clear proportional

relationship between prolactin and tumor size. Incorporation of a size-adjusted prolactin index into routine preoperative assessment may improve diagnostic accuracy and help guide appropriate first-line treatment.

Conflict of interest: Nil

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