International Journal of Academic Health and Medical Research (IJAHMR)
ISSN: 2643-9824
Vol. 10 Issue 7 July - 2026, Pages: 33-37

Diagnostic Performance of the Parathyroid Function Index, Wisconsin Index, and Calcium/Phosphate Ratio in Differentiating Primary hyperparathyroidism from Vitamin D–Deficient Secondary Hyperparathyroidism: A Study of 106 Cases

Leila Rouimi [1], Khawla Salhi [1], Mohammed Amine Essafi [1-2-3], Zineb El Azime [1-2-3], Hayat Aynaou [1-2-3], Houda Salhi [1-2-3]

1- Department of Endocrinology, Diabetology and Nutrition – Hassan II University Hospital.
2- Faculty of Medicine and Pharmacy, Sidi Mohamed Ben Abdellah University,
Fez, Morocco
3- Epidemiology and Health Sciences Research Laboratory.in Health Sciences,

[1] Leila.rouimi@usmba.ac.ma, khawla.salhi@usmba.ac.ma
[1-2-3] Dr.essafiamine@gmail.com, zineb.elazime@gmail.com, ayhayat00@gmail.com, salhihouda@gmail.com

***Abstract**: Background: Serum 25-hydroxyvitamin D (25OHD) levels significantly influence parathyroid hormone (PTH) levels in primary hyperparathyroidism (PHPT). Vitamin D repletion to exclude secondary hyperparathyroidism (SHPT) is essential, particularly with the emergence of normocalcemic primary hyperparathyroidism (normocalcemic PHPT). This may delay the diagnosis of PHPT; diagnostic tools such as Pf index : Parathyroid Function Index, the WIN index, and the calcium-to-phosphate (Ca/P) ratio may facilitate early diagnosis.Aims: evaluate the diagnostic accuracy of these three tools in differentiating between primary hyperparathyroidism and vitamin D deficiency-induced secondary hyperparathyroidism, and to establish a diagnostic cutoff threshold to avoid overdiagnosis of primary hyperparathyroidism and thereby prevent unnecessary parathyroidectomies. Patients and Methods: Our retrospective comparative analytical study included 106 patients followed for primary hyperparathyroidism or vitamin D deficiency-induced secondary hyperparathyroidism. Patients were divided into three groups as follows: Group 1: PHPT, Group 2: normocalcemic PHPT (NC-PHPT), and Group 3: vitamin D deficiency-associated SHPT. The WIN index (Ca × PTH), the calcium-to-phosphate ratio (Ca/P), and the Pf index (Ca × PTH / phosphate) were calculated and analyzed across the three groups. Statistical analysis was performed using SPSS version 26 software. Quantitative variables among the three groups were compared using ANOVA test. The diagnostic performance of the different indices was evaluated using Receiver Operating Characteristic (ROC) curve analysis, with assessment of the balance between sensitivity and specificity. A p-value of 0.05 was used to determine statistical significance. Main results: Group 1 had the highest values of corrected serum calcium, PTH, and Pf index (p < 0.05). The WIN index was significantly higher in Group 1 compared to Group 2 (p = 0.003) and Group 3 (p < 0.001). The corrected Ca/P ratio was significantly higher in Group 1 compared to Group 3 (p < 0.001). Finally, the Pf index was significantly higher in Group 1 compared to Groups 2 and 3 (p = 0.002). The area under the ROC curve (AUC) for the Pf index in ROC analysis for the diagnosis of PHPT was the highest at 0.845. Accordingly, it provided a sensitivity of 89% and a specificity of 60% above the cutoff value of 59. A Ca/P ratio > 3.2 suggested PHPT with a sensitivity of 80% and a specificity of 70%. A WIN index > 51 suggested PHPT with a sensitivity of 88% and a specificity of 70%. Conclusion: The Pf index provided excellent diagnostic accuracy in differentiating PHPT from vitamin D deficiency-associated SHPT. This simple tool may be useful in guiding timely decision-making processes regarding the initiation of vitamin D supplementation versus parathyroidectomy for PHPT.*

Keywords: *pfindex, vitamin-d deficiency, secondary hyperparatiodism, parathyroid function test, primary hyperparathyroidism*

1. INTRODUCTION

Patients with primary hyperparathyroidism (PHPT) may be asymptomatic, and some of them develop a normocalcemic form (NC-PHPT). Similarly, subjects with 25OHD deficiency may remain asymptomatic while presenting normal serum calcium levels associated with elevated PTH. In this case, the diagnosis of secondary hyperparathyroidism related to vitamin D deficiency is generally established. Thus, the distinction between PHPT, NC-PHPT, and secondary HPT due to hypovitaminosis D remains complex when based solely on serum calcium or PTH levels. Hence the emergence of three indices: pf index, WIN index, and Ca/P ratio.[1]

McKenna [2] observed that during the winter, 40% of native young, healthy individuals in Central and Southern Europe suffered from vitamin D insufficiency, which was frequently associated with increased PTH levels. Furthermore, 14% of healthy adult volunteers had 25(OH)D insufficiency and increased PTH levels in major French research

Aims: evaluate the diagnostic accuracy of these three tools in differentiating between primary hyperparathyroidism and

International Journal of Academic Health and Medical Research (IJAHMR)
ISSN: 2643-9824
Vol. 10 Issue 7 July - 2026, Pages: 33-37

vitamin D deficiency-induced secondary hyperparathyroidism, and to establish a diagnostic cutoff threshold to avoid overdiagnosis of primary hyperparathyroidism and thereby prevent unnecessary parathyroidectomies

2. MATERIALS AND METHODS:

This is a retrospective comparative analytical study of patients between January 2022 and January 2024 conducted in the Department of Endocrinology, Diabetology, Metabolic Diseases and Nutrition at Hassan II University Hospital in Fez. We included all patients followed in our department for primary hyperparathyroidism (with biological and then histopathological confirmation) or secondary hyperparathyroidism due to hypovitaminosis D (defined by normalization of PTH 6 months after vitamin D supplementation). Patients followed for secondary hyperparathyroidism such as renal failure and unusable medical records were excluded.

All patients underwent measurements of serum calcium, albumin, PTH, Ph, and 25OHD. Patients were divided into 3 groups as follows: group 1: PHPT, group 2: NC-PHPT, and group 3: secondary HPT due to vitamin D deficiency.

The WIN index: Ca × PTH, the ratio: Ca/Ph, and finally the pf index: Ca × PTH / phosphate were calculated and analyzed in the 3 groups. The units used were as follows: serum PTH (pmol/L), albumin-corrected calcium (mmol/L), phosphate (mmol/L).

Statistical analysis was performed using SPSS 26 software. Quantitative variables were expressed as mean ± standard deviation, and qualitative variables as frequency and percentage. Quantitative variables of the 3 groups were compared using ANOVA test.

The diagnostic capacity of the different indices was evaluated using ROC (Receiver Operating Characteristic) curve analysis, and ROC curves were generated to analyze the balance between sensitivity and specificity. A p-value of 0.05 was used to determine statistical significance.

Consent was obtained or waived by all participants in this study.

3. RESULTS:

Out of 106 patients, the mean age was 56.50 years ± 13.24, with 82.10% being women. 62.3% of patients belonged to group 1, 17% to group 2, and 20.7% to group 3. The mean age in group 1 was 54.10 years ± 12.66, in group 2: 57 years ± 15.40, and in group 3: 55.70 years ± 16.5. No statistically significant difference was observed between the groups in terms of age and sex.

The mean corrected serum calcium in mmol/L was 3.46 ± 0.81 for group 1 vs 2.5 ± 0.10 for group 2 vs 2.15 ± 0.15 for group 3.

The mean PTH in pmol/L was 136 ± 15 for group 1 vs 95 ± 14.6 for group 2 vs 71 ± 12.9 for group 3.

Group 1 had the highest values of corrected serum calcium, PTH, and PF index (all P values < 0.001).

The WIN index was significantly higher in group 1 compared to group 2 (p = 0.003) and group 3 (p < 0.001). The Ca/Ph ratio was significantly higher in group 1 compared to group 3 (p < 0.001). Finally, the pf index was significantly higher in group 1 compared to groups 2 and 3 (p = 0.002) (Table 1).

The area under the curve (AUC) for pf index in the ROC analysis for the diagnosis of PHPT was 0.845. Consequently, it provided a sensitivity of 89% and a specificity of 60% above the cutoff value of 59, and a sensitivity of 93% and a specificity of 30% above the cutoff value of 34 (Table 2). The AUC, sensitivity, and specificity rates of the pf index curve were higher than those of the WIN index and Ca/Ph ratio curves (Figure 1, Table 2).

A Ca/Ph ratio > 3.2 suggested PHPT with a sensitivity of 80% and a specificity of 70%. A WIN index > 51 suggested PHPT with a sensitivity of 88% and a specificity of 70%.

Table 1: *Comparison of the three indices values between the different groups and significance threshold.*

Index	Groupe	Vs Groupe	Significance p
Win Index	**1: HPTP hypercalcaemic**	**2**	**0.003**
		3	**0.001**
	2: HPTP normocalcaemic	**1**	**0.003**
		3	**1.00**
	3: HPTS vitamin D deficiency	**1**	**0.001**
		2	**1.00**
Ca/ph index	**1**	**2**	**0.064**
		3	**0.001**
	2	**1**	**0.064**
		3	**0.61**

International Journal of Academic Health and Medical Research (IJAHMR)
ISSN: 2643-9824
Vol. 10 Issue 7 July - 2026, Pages: 33-37

	3	**1**	**0.00**
		2	**0.61**
Pf Index	**1**	**2**	**0.023**
		3	**0.002**
	2	**1**	**0.023**
		3	**1.00**
	3	**1**	**0.002**
		2	**1.00**

Figure 1: *ROC curves of pf index, WIN index, and Ca/Ph ratio.*

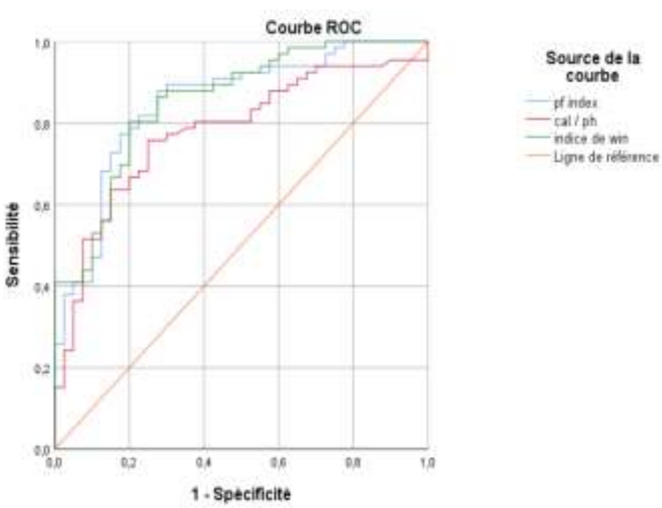

Table 2: *Sensitivity, specificity of pf index, WIN index, and Ca/Ph ratio from ROC curve analysis in the diagnosis of primary hyperparathyroidism (PHPT).*

Test result variable(s)	Value	Sensibility	Specificity	Area under the curve
Pf index	59	89 %	60 %	0,845
	34	93 %	30 %	
WIN index	51	88 %	70 %	0,825
Cal/ph	3.2	78 %	70 %	0,779

4. DISCUSSION :

According to the pathogenesis of PHPT and VD-SHPT, several authors have noted relatively higher serum calcium and parathormone concentrations associated with lower serum phosphate concentrations in PHPT, whereas in VD-SHPT these variations were less pronounced. When faced with elevated PTH values associated with hypovitaminosis D, should vitamin D supplementation be initiated, should normalization of vitamin status be awaited, or should potential topographic diagnosis and parathyroid surgery be delayed? Hence the emergence of several indices that can guide clinicians at the initial diagnostic stage.

The pf index was the first index designed to differentiate between primary hyperparathyroidism and secondary hyperparathyroidism. According to our results, the pf index was superior to other indices as it likely reflects the interactions between multiple parameters: serum calcium and phosphorus concentrations and PTH.

In a previous study of 128 patients in China in 2020, Yanhong Guo et al. reported that the pf index had the best AUC: 0.94, and a pf index > 34 had a sensitivity of 93% and a specificity of 30% (Table 3) [1].

Table 3: *New parathyroid function index for differentiating between primary and secondary hyperparathyroidism: a case-control study [1]*

Parameter	Sensibility (%)	Specificity (%)	AUC
PFindex > 34	**96,9**	**97,6**	**0,945**
Calcium > 2,51	**95,3**	**97,6**	**0,929**

PTH > 11,96	**85,1**	**100**	**0,851**
Calcium × PTH > 35,43	**93,0**	**97,6**	**0,906**
Ca/P > 2,71	**91,4**	**93,9**	**0,853**

Another study by Harinarayan et al. in 2022, involving 52 patients, showed similar results: the pf index had a perfect AUC = 1, and a pf index > 30.29 had a sensitivity of 100% and a specificity of 100%. A WIN index > 22.41 had a sensitivity of 100% and a specificity of 99.87%. Finally, a Ca/Ph ratio > 2.52 had a sensitivity of 100% and a specificity of 96.89% (Table 4) [3].

Table 4: *Parathyroid function index for differentiating between primary and secondary hyperparathyroidism and threshold value used [3]*

Parameter	Seuil	Sensibility (%)	Specificity (%)	AUC
PFindex	**> 30,29**	**100**	**100**	**1**
Calcium	**> 2,62**	**100**	**98,96**	**0,99**
PTH	**> 9,18**	**100**	**99,87**	**1**
Calcium × PTH	**> 22,41**	**100**	**99,87**	**1**
Ca/P	**> 2,52**	**100**	**96,89**	**0,97**

A case-control study of 219 Turkish patients in 2022 reported by Murat Bulut Özkan et al. (using the same calcium, PTH, and phosphorus units as our study) showed that the pf index once again had the best AUC: 0.951, and a pf index > 32.78 had a sensitivity of 91.9% and a specificity of 90.9%. A WIN index > 26 had a sensitivity of 89.7% and a specificity of 90.9%. Finally, a Ca/Ph ratio > 3.3 had a sensitivity of 89.7% and a specificity of 88.6% (Table 5) [4].

Table 5: *Sensitivity, specificity, and AUC of serum calcium, PTH, calcium × PTH product, and Pf index in the diagnosis of HPTP [4]*

Parameter	Seuil	Sensibility (%)	Specificity (%)	AUC
PFindex	**32,78**	**91,9**	**90,9**	**0,951**
Cal/Ph	**3,3**	**89,7**	**88,6**	**0,944**
Calcium × PTH (WIN)	**26**	**89,7**	**88,6**	**0,942**

Our higher cutoff values are due to higher PTH and calcium values, probably resulting from selection bias: our department manages more severe hypercalcemia cases, sometimes with diagnostic delay.

The strength of our work lies in its statistical analysis of indices that are easy to calculate during consultation, allowing time and cost savings while facilitating the differential diagnosis of the disease.

On the other hand, we acknowledge certain limitations of our study due to its retrospective nature. Moreover, the general vitamin D deficiency observed in Moroccan society could influence the results. Additionally, the small number of patients constitutes a limitation, even though our population was twice as large as in the study by Harinarayan et al. We did not include a control group composed of healthy individuals. Obtaining these data proved difficult in our study.

Based on all these studies and ours, the pf index remains the most reliable index compared to the WIN index and the calcium/Ph ratio, and should have a real impact on our daily practice. It can be used as a complement to standard workup, especially in cases of normocalcemic PHPT. To date, there are no recommendations on the exact cutoff value to adopt for the pf index, but the higher the pf index, for example > 34, the more it should alert clinicians to possible PHPT even in cases of normocalcemia.

-Our study has several strengths; however, its main limitations are retrospective design, single-center study, a relatively small sample size and a lack of external validation of the cut-off values

Therefore, prospective multicenter studies are needed to validate these findings and define standardized cut-off values. This is an area for future research

5. Conclusion:

The pf index provided excellent diagnostic power to differentiate PHPT from VD-SHPT. This simple first-line tool can be useful for guiding timely decision-making processes regarding the initiation of vitamin D treatment or surgery for PHPT. It should be used as a complement to standard workup. To date, there are no recommendations on the exact cutoff value to adopt for the pf index, but the higher the pf index, the more it should alert clinicians to possible PHPT even in cases of normocalcemia.

The major benefit of these indices is to provide initial diagnostic guidance, allowing deferral of potential topographic diagnosis and unnecessary parathyroid surgery.

Research perspectives: Further studies are needed to establish a universal recommendation with a standardized cutoff value.

6. References :

(1) Guo, Y.; Wang, Q.; Lu, C.; Fan, P.; Li, J.; Luo, X.; Chen, D. New Parathyroid Function Index for the Differentiation of Primary and Secondary Hyperparathyroidism: A Case-Control Study. *BMC Endocr. Disord.* **2020**, *20* (1), 5. https://doi.org/10.1186/s12902-019-0487-8.

(2) Differences in vitamin D status between countries in young adults and the elderly. McKenna MJ. Am J Med. 1992;93:69–77. doi: 10.1016/0002-9343(92)90682-2.
(3) Harinarayan, C. V.; Ashok, H.; Munigoti, S. P.; Tandon, S.; Sarma, K. V. S.; Tandon, A. S.; Chandy, S. P.; Chandran, D. Vitamin D status in primary hyperparathyroidism in 1990 and thence – Emergence of normocalcaemic presentation and diagnostic challenges – Utility of parathyroid function index. *J. Clin. Sci. Res.* **2022**, *11* (3), 167. https://doi.org/10.4103/jcsr.jcsr_44_22.

(4) Özkan, M. B.; Turhan, V. B. Use of Parathyroid Function Index and Wisconsin Index to Differentiate Primary Hyperparathyroidism from Secondary Hyperparathyroidism: A Case-Control Study. *Cureus 14* (3), e23043. https://doi.org/10.7759/cureus.23043.

(5) Madeo B, Kara E, Cioni K, Vezzani S, Trenti T, Santi D, et al. The serum calcium-to-phosphorus (Ca/P) ratio is a simple, inexpensive and accurate tool for the diagnosis of primary hyperparathyroidism. JBMR Plus 2018;2:109–17
(6) Woodhouse NJ, Doyle FH, Joplin GF. Vitamin D deficiency and primary hyperparathyroidism. The Lancet 1971;2:283–6.
(7) Fraser WD. Hyperparathyroïdie. Lancet. 2009;374(9684):145–58.
(8) Jayasena CN, Modi M, Palazzo F, De Silva A, Donaldson M, Meeran K, et al. Associations between serum 25-hydroxyvitamin D and circulating PTH, phosphate and calcium in patients with primary hyperparathyroidism. Clin Endocrinol. 2013;78(6):838–43.
(9) Souberbielle JC, Maury E, Friedlander G, Cormier C. Vitamin D and primary hyperparathyroidism (PHPT). J Steroid Biochem Mol Biol. 2010;121(1–2):199–203.
(10) Holick MF, Binkley NC, Bischoff-Ferrari HA, Gordon CM, Hanley DA, Heaney RP, et al. Assessment, treatment and prevention of vitamin D deficiency: clinical practice guidelines from the Endocrine Society. J Clin Endocrinol Metab. 2011;96(7):1911–30.
(11) Peacey SR, Wright D, Harries MJ. Échec de la normalisation de l'hormone parathyroïdienne lors du traitement de la carence en vitamine D chez les patients asiatiques. Clin Endocrinol. 2004;61(5):603–6.
(12) Shin YH, Kim KE, Lee C, Shin HJ, Kang MS, Lee HR, et al. High prevalence of vitamin D insufficiency or deficiency among young adolescents in Korea. Eur J Pediatr. 2012;171(10):1475–80.
(13) Medical management of asymptomatic primary hyperparathyroidism: proceedings of the third international workshop. Khan A, Grey A, Shoback D. J Clin Endocrinol Metab. 2009;94:373–381. doi: 10.1210/jc.2008-1762.
(14) Usefulness of the Wisconsin and CaPTHUS indices for predicting multiglandular disease in patients with primary hyperparathyroidism in a southern European population. Serradilla-Martín M, Palomares-Cano A, Cantalejo-Díaz M, et al. Gland Surg. 2021;10:861–869. doi: 10.21037/gs-20-857.
(15) Progressive rise in the prevalence of asymptomatic primary hyperparathyroidism in India: data from PHPT registry. Arya AK, Kumari P, Bhadada SK, et al. J Bone Miner Metab. 2021;39:253–259. doi: 10.1007/s00774-020-01142-w.
(16) Guidelines for the management of asymptomatic primary hyperparathyroidism: summary statement from the Fourth International Workshop. Bilezikian JP, Brandi ML, Eastell R, Silverberg SJ, Udelsman R, Marcocci C, Potts JT Jr. J Clin Endocrinol Metab. 2014;99:3561–3569. doi: 10.1210/jc.2014-1413.
(17) Creation of a "Wisconsin index" nomogram to predict the likelihood of additional hyperfunctioning parathyroid glands during parathyroidectomy. Mazeh H, Chen H, Leverson G, Sippel RS. Ann Surg. 2013;257:138–141. doi: 10.1097/SLA.0b013e31825ffbe1
(18) Evaluation of Wisconsin and CaPTHUS indices usefulness for predicting monoglandular and multiglandular disease in patients with primary hyperparathyroidism through the analysis of a single-center experience. De Pasquale L, Lori E, Bulfamante AM, Felisati G, Castellani L, Saibene AM. Int J Endocrinol. 2021;2021:2040284. doi: 10.1155/2021/2040284.