Diagnostic Performance of Plain Film, Ultrasonography, and Computed Tomography in Nasal Bone Fractures: A Systematic Review

Le rendement diagnostique des clichés sans préparation, de l'échographie et de la tomodensitométrie en cas de fractures de l'os nasal : une analyse systématique

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Abstract

Purpose: The aim of this study was to compare the diagnostic performance (accuracy, sensitivity, specificity, positive predictive value, and negative predictive value) of plain film (PF), ultrasonography (USG), and computed tomography (CT) in diagnosing nasal bone fractures (NBFs). **Methods:** In a search of PubMed and Scopus, "nasal bone fracture" AND "X-ray OR CT OR USG OR MRI" were searched. Among the 369 titles from PubMed and 379 titles from Scopus, 257 duplicate titles were excluded and 491 titles were reviewed. Among them, 36 full articles were reviewed. From these, 21 were excluded and 1 mined article was added; thus, 16 articles were reviewed. **Results:** The accuracy of CT ($94.4\% \pm 2.3\%$) was significantly higher ($P < .001$) than that of USG ($85.0\% \pm 3.6\%$). The accuracy of USG was significantly higher ($P < .001$) than that of PF ($67.7\% \pm 4.7\%$). Computed tomography ($89.3\% \pm 3.1\%$) and USG ($87.2\% \pm 3.3\%$) were significantly more sensitive than PF ($P < .001$ and $P < .001$, respectively). The specificity of CT ($94.2\% \pm 2.3\%$) was significantly higher ($P = .001$) than that of USG ($87.4\% \pm 3.3\%$). The specificity of USG was significantly higher ($P < .001$) than that of PF ($67.8\% \pm 4.7\%$). Among the PF techniques, combining a lateral view and the Water's view ($71.8\% \pm 4.5\%$) had significantly higher accuracy than a lateral view alone ($62.4\% \pm 4.8\%$) or the Water's view alone ($61.0\% \pm 4.9\%$). In USG, there was no significant difference ($P = .300$) in accuracy among lateral and dorsal views ($95.8\% \pm 2.0\%$), a lateral view alone ($84.2\% \pm 3.7\%$), and a dorsal view alone ($84.2\% \pm 3.6\%$). **Conclusion:** The results of this review might be helpful in choosing the most appropriate diagnostic tool in patients suspected having NBF.

Résumé

Objectif : La présente étude visait à comparer le rendement diagnostique (précision, sensibilité, spécificité, valeur prédictive positive et valeur prédictive négative) du film radiographique (FR), de l'échographie (ÉG) et de la tomodensitométrie (TDM) pour diagnostiquer les fractures de l'os nasal (FON). **Méthodologie :** Les auteurs ont cherché les termes *nasal bone fracture* ET *X-ray* OU *CT* OU *USG* OU *MRI* dans PubMed et Scopus. Parmi les 369 articles tirés de PubMed et les 379 articles tirés de Scopus, ils ont exclu 257 articles dédoublés et examiné 491 articles. De ce nombre, ils ont revu 36 articles intégraux. Ils en ont exclu 21, ont ajouté un article extrait des précédents et ont analysé 16 articles. **Résultats :** La TDM ($94,4\% \pm 2,3\%$) était considérablement plus précise ($P < 0,001$) que l'ÉG ($85,0\% \pm 3,6\%$). L'ÉG était considérablement plus précise ($P < 0,001$) que le FR ($67,7\% \pm 4,7\%$). La TDM ($89,3\% \pm 3,1\%$) et l'ÉG ($87,2\% \pm 3,3\%$) étaient considérablement plus sensibles que le FR ($P < 0,01$ et $P < 0,001$, respectivement). La TDM ($94,2\% \pm 2,3\%$) était considérablement plus spécifique ($P = 0,001$) que l'ÉG ($87,4\% \pm 3,3\%$). L'ÉG était

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considérablement plus spécifique ($P < 0,001$) que le FR ($67,8 \% \pm 4,7 \%$). Parmi les techniques de FR, la combinaison de la vue latérale et de la vue de Water ($71,8 \% \pm 4,5 \%$) était considérablement plus précise que la vue latérale seule ($62,4 \% \pm 4,8 \%$) ou que la vue de Water seule ($61,0 \% \pm 4,9 \%$). La précision des vues latérale et dorsale ($95,8 \% \pm 2,0 \%$), de la vue latérale seule ($84,2 \% \pm 3,7 \%$) et de la vue dorsale seule ($84,2 \% \pm 3,6 \%$) de l'ÉG n'était pas statistiquement significative ($P = 0,300$).

Conclusion : Les résultats de la présente analyse peuvent être utiles pour choisir l'outil diagnostique le mieux adapté aux patients susceptibles d'avoir une FON.

Keywords

nasal bone, fractures, bone, diagnosis, tomography, X-ray computed, ultrasonography, X-ray film, sensitivity and specificity

Introduction

The nose is the most prominent central part of the face, and fracture of the nasal bone is the most common type of facial fracture.¹ Many articles have provided information on the efficiency of several radiological tools for diagnosing nasal bone fractures (NBFs); however, few studies have presented a systematic review. Becker reported that plain film (PF) radiographs revealed definite fractures in 53% of the cases included in that study.² The reliability of PF radiographs for diagnosing NBFs was found to be 82% in our previous study.¹

The aim of this study was to compare the diagnostic performance (accuracy, sensitivity, specificity, positive predictive

value [PPV], and negative predictive value [NPV]) of PF, ultrasonography (USG), and computed tomography (CT) in diagnosing NBFs.

Materials and Methods

In a search of PubMed and Scopus, the search terms “nasal bone fracture” AND “X-ray OR CT OR USG OR MRI” were used. Studies that did not discuss the radiological diagnosis of NBFs were excluded. No restrictions on language or publication form were imposed. All articles were read by 2 independent reviewers who extracted the data.

Figure 1. Selection process of the articles included in this study.

Table 1. Diagnostic Performance of Each Method for Nasal Bone Fracture.

Diagnostic performances	PF	USG	CT	Total
Number (%)	2020 (43.6)	1480 (32.0)	1128 (24.4)	4628 (100.0)
Accuracy (%)	1188/1755 (67.7 ± 4.7)	1019/1199 (85.0 ± 3.6)	980/1038 (94.4 ± 2.3)	3187/3992 (79.8 ± 4.0)
Sensitivity (%)	911/1403 (64.9 ± 4.8)	994/1140 (87.2 ± 3.3)	800/896 (89.3 ± 3.1)	2705/3439 (78.7 ± 4.1)
Specificity (%)	660/973 (67.8 ± 4.7)	799/914 (87.4 ± 3.3)	652/692 (94.2 ± 2.3)	2111/2579 (81.9 ± 3.9)
PPV (%)	967/1178 (82.1 ± 3.8)	922/1002 (92.0 ± 2.7)	268/300 (89.3 ± 3.1)	2157/2480 (87.0 ± 3.4)
NPV (%)	507/981 (51.7 ± 5.0)	717/850 (84.4 ± 3.6)	922/1002 (92.0 ± 2.7)	2146/2833 (75.8 ± 4.3)

Abbreviations: CT, computed tomography; NPV, negative predictive value; PF, plain film; PPV, positive predictive value; USG, ultrasonography.

Table 2. Diagnostic Performance of Plain Film for Nasal Bone Fracture.

Author	Year	Location	N	Accuracy	Sensitivity	Specificity	PPV	NPV
Thiede ⁴	(2005)	Lateral	126	94/126	61/74	33/52	61/68	33/38
		Occipitontental	126	62/126	43/82	19/44	43/55	19/35
		Pyramid	126	83/126	67/84	16/42	67/84	16/25
		Subtotal	378	239/378	171/240	68/138	171/207	68/98
Atiggechi ¹⁵	(2014)	Lateral	118	65/118	59/118	85/118	99/118	38/118
		Water's	118	66/118	63/118	77/118	97/118	76/118
		Lateral + Water's	118	73/118	68/118	68/118	97/118	40/118
		Subtotal	354	204/354	190/354	230/354	293/354	154/354
Masoomi ¹⁷	(2015)	Lateral + Dorsum	124	84/124	57/89	27/35	57/65	27/59
		Water's + Wall	124	84/124	29/54	55/70	29/44	55/80
		Subtotal	248	168/248	86/143	82/105	86/109	82/139
Gürkov ⁵	(2008)	Dorsum	80	72/80	52/59	20/21	52/53	20/27
		Lateral	80	33/80	18/64	15/16	18/19	15/61
		Subtotal	160	105/160	70/123	35/37	70/72	35/88
Lee ¹⁸	(2016)	Lateral	59	—	34/59	34/59	21/59	46/59
		Midline	31	—	19/31	18/31	18/31	26/31
		Subtotal	90	—	53/90	52/90	39/90	72/90
Lou ¹²	(2012)	Lateral	23	18/23	20/23	6/23	20/23	8/23
		Skull AP + Lat	17	10/17	8/17	17/17	17/17	5/17
		Water's	12	5/12	2/12	12/12	12/12	4/12
		Subtotal	52	33/52	30/52	35/52	49/52	17/52
Zhong ¹⁶	(2014)	—	202	161/202	—	—	—	—
Lee ⁶	(2009)	Lateral + Water's	140	110/140	108/138	2/2	108/108	2/32
Baek ¹³	(2013)	Coronal + Lateral	108	71/108	67/88	4/20	67/83	4/25
Mohammadi ⁷	(2009)	Lateral + Water's	103	—	79/103	84/103	84/103	73/103
Mohammadi ¹⁰	(2011)	Lateral + Water's	72	—	57/72	68/72	—	—
Kunitskil ¹¹	(2013)	—	60	48/60	—	—	—	—
Çil ¹⁴	(2013)	—	45	41/45	—	—	—	—
Dorobisz ³	(1983)	Lateral + Water's	8	8/8	—	—	—	—
Total			2020	1188/1755 (67.7)	911/1403 (64.9)	660/973 (67.8)	967/1178 (82.1)	507/981 (51.2)

Abbreviations: N, number of patient; NPV, negative predictive value; PPV, positive predictive value.

The data were summarized. A statistical analysis was performed using SPSS 19.0 (IBM Corp, Armonk, New York).

Among the 748 titles (369 titles from PubMed and 379 titles from Scopus), 257 duplicate titles were excluded and 491 titles were reviewed. Among the 491 remaining titles, 434 were excluded, resulting in 57 abstracts that met our inclusion criteria ("nasal bone fracture" and "radiological diagnosis" appeared in the title). Studies that did not allow an evaluation of NBFs and the diagnosis thereof were excluded. Based on these exclusion criteria, 21 abstracts were excluded and 36 full articles providing data on NBF, and diagnosis rates were reviewed. In addition to these 36 articles, 1 externally

identified article was added, resulting in 37 articles. Of those 37 articles, 21 were excluded because they did not have quantitative values (11 studies), were not relevant (5 studies), or were not original articles (5 studies). Thus, 16 articles were reviewed (Figure 1).³⁻¹⁸ We followed "Preferred Reporting Items for Systematic Reviews and Meta-Analyses" guidelines in this study.¹⁹

Results

A total of 4628 cases of NBFs from 16 articles were analyzed.³⁻¹⁸ For the diagnosis of NBFs, PF (n = 2020, 43.6%), USG

Table 3. Diagnostic Performance of Ultrasonography for Nasal Bone Fracture.

Author	Year	Location	N	Accuracy	Sensitivity	Specificity	PPV	NPV
Thiede ⁴	(2005)	Dorsum	126	72/126	34/74	36/52	35/40	36/56
		Lateral	126	88/126	57/82	31/44	57/64	31/47
		Nasal pyramid	126	83/126	65/84	25/42	65/75	25/38
		Subtotal	378	243/378	158/240	92/138	158/179	92/141
Masoomi ¹⁷	(2015)	Dorsum	124	119/124	85/89	34/35	85/86	34/38
		Lateral	124	117/124	48/54	69/70	48/49	69/75
		Subtotal	248	236/248	133/143	103/105	133/135	103/113
Gürkov ⁵	(2008)	Dorsum	80	78/80	58/59	20/21	58/59	20/21
		Lateral	80	75/80	63/64	12/16	63/67	12/13
		Subtotal	160	153/160	121/123	325/37	121/126	32/34
Lee ¹⁸	(2015)	Lateral	59	—	44/59	45/59	31/59	50/59
		Midline	31	—	25/31	28/31	23/31	29/31
		Subtotal	90	—	69/90	73/90	54/90	79/90
Lee ¹²	(2009)	—	140	140/140	140/140	140/140	140/140	140/140
Atiggechi ¹⁵	(2014)	Lateral	118	97/118	99/118	89/118	107/118	72/118
Mohammadi ⁷	(2009)	—	103	—	93/103	101/103	101/103	90/103
Mohammadi ¹⁰	(2011)	—	72	—	72/72	66/72	—	—
Lou ¹²	(2012)	Dorsum	71	69/71	71/71	63/71	68/71	71/71
Kunitskii ¹¹	(2013)	—	60	58/60	—	—	—	—
Javadrashid ⁹	(2011)	Dorsum + Lateral	40	23/24	38/40	40/40	40/40	38/40
Total			1480	1019/1199 (85.0)	994/1140 (87.2)	799/914 (87.4)	922/1002 (92.0)	717/850 (84.4)

Abbreviations: N, number of patient; NPV, negative predictive value; PPV, positive predictive value.

Table 4. Diagnostic Performance of Computed Tomography for Nasal Bone Fracture.

Author	Year	Location	N	Accuracy	Sensitivity	Specificity	PPV	NPV
Kim ⁸	(2010)	Axial-ob1	145	133/145	129/145	135/145	—	—
		Axial-ob2	145	131/145	116/145	138/145	—	—
		Sagittal-ob1	145	143/145	141/145	144/145	—	—
		Sagittal-ob2	145	137/145	128/145	140/145	—	—
		Subtotal	580	544/580	514/580	557/580	—	—
Lee ¹⁸	(2015)	Midline	31	—	25/31	26/31	21/31	29/31
		Lateral	59	—	54/59	50/59	40/59	57/59
		Subtotal	90	—	79/90	76/90	61/90	86/90
Zhong ¹⁶	(2014)	—	202	202/202	—	—	—	—
Lee ¹²	(2009)	—	140	129/140	128/138	1/2	128/129	1/11
Baek ¹³	(2013)	—	108	97/108	79/88	18/20	79/81	18/27
Dorobisz ³	(1983)	—	8	8/8	—	—	—	—
Total			1128	980/1038 (94.4)	800/896 (89.3)	652/692 (94.2)	268/300 (89.3)	105/128 (82.0)

Abbreviations: N, number of patient; NPV, negative predictive value; PPV, positive predictive value.

(n = 1480, 40.0%), and CT (n = 1128, 14.4%) were used (Table 1).

Accuracy

The accuracy of CT (94.4% ± 2.3%) was the highest among the 3 methods, followed by USG (85.0% ± 3.6%) and PF (67.7% ± 4.7%). Computed tomography had significantly higher accuracy than USG ($P < .001$ [analysis of variance [ANOVA], Scheffe method]). Ultrasonography had significantly higher accuracy than PF ($P < .001$ [ANOVA, Scheffe method]), Tables 2-4, Figure 2).

In PF, a lateral view with the Water's view (71.8% ± 4.5%) had the highest accuracy, followed by the lateral view alone (62.4% ± 4.8%) and the Water's view alone (61.0% ± 4.9%).

Figure 2. Diagnostic performance of each method. CT indicates computed tomography; NPV, negative predictive value; PF, plain film; PPV, positive predictive value; USG, ultrasonography. * $P < .05$.

Table 5. Diagnostic Performance of Each Method of Plain Film for Nasal Bone Fracture.

Method	Author	Year	N	Accuracy	Sensitivity	Specificity	PPV	NPV
Lateral	Thiede ⁴	(2005)	126	94/126	61/74	33/52	61/68	33/38
	Masoomi ¹⁷	(2015)	124	84/124	57/89	27/35	57/65	27/59
	Atiggechi ¹⁵	(2014)	118	65/118	59/118	85/118	99/118	38/118
	Gürkov ⁵	(2008)	80	33/80	18/64	15/16	18/19	15/61
	Lee ¹⁸	(2015)	59	—	34/59	34/59	21/59	46/59
	Lou ¹²	(2012)	23	18/23	20/23	6/23	20/23	8/23
	Subtotal		530	294/471	249/427	200/303	276/352	167/358
Water's	Masoomi ¹⁷	(2015)	124	84/124	29/54	55/70	29/44	55/80
	Atiggechi ¹⁵	(2014)	118	66/118	63/118	77/118	97/118	76/118
	Lou ¹²	(2012)	12	5/12	2/12	12/12	12/12	4/12
	Subtotal		254	155/254	94/184	144/200	138/174	135/210
Lateral + Water's	Lee ¹²	(2009)	140	110/140	108/138	2/2	108/108	2/32
	Atiggechi ¹⁵	(2014)	118	73/118	68/118	68/118	97/118	40/118
	Mohammadi ⁷	(2009)	103	—	79/103	84/103	84/103	73/103
	Mohammadi ¹⁰	(2011)	72	—	57/72	68/72	—	—
	Dorobisz ³	(1983)	8	8/8	—	—	—	—
	Subtotal		441	191/266	312/431	222/295	289/329	115/253
Total			1225	640/991 (64.6)	655/1042 (62.9)	566/798 (70.9)	703/855 (82.2)	417/821 (50.8)

Abbreviations: N, number of patient; NPV: negative predictive value; PPV, positive predictive value.

Figure 3. Diagnostic performance of plain film. NPV indicates negative predictive value; PPV, positive predictive value. * $P < .05$.

A lateral view with the Water's view had significantly higher accuracy than a lateral view alone ($P = .038$ [ANOVA, Scheffe method]) or the Water's view alone ($P = .037$, [ANOVA, Scheffe method]). However, there was no significant difference between a lateral view and the Water's view ($P = .932$ [ANOVA, Scheffe method], Table 5, Figure 3).

In USG, lateral and dorsal views (LD) had the highest accuracy ($95.8\% \pm 2.0\%$), followed by a lateral view alone (L, $84.2\% \pm 3.7\%$) and a dorsal view alone (D, $84.2\% \pm 3.6\%$). However, there was no significant difference among them ($P = .300$ [ANOVA, Scheffe method]; Table 6, Figure 4).

Sensitivity

The sensitivity of CT ($89.3\% \pm 3.1\%$) was the highest among the 3 methods, followed by USG ($87.2\% \pm 3.3\%$) and PF ($64.9\% \pm 4.8\%$). Computed tomography and USG had higher sensitivity than PF ($P < .001$ and $P < .001$, respectively [ANOVA, Scheffe method]). However, there was no

significant difference between USG and CT ($P = .492$ [ANOVA, Scheffe method]; Tables 2-4, Figure 2).

In PF, a lateral view with the Water's view ($72.4\% \pm 4.5\%$) had the highest sensitivity, followed by a lateral view alone ($58.3\% \pm 4.9\%$) and the Water's view alone ($51.0\% \pm 5.0\%$). A lateral view with the Water's view had significantly higher sensitivity than a lateral view alone ($P < .001$ [ANOVA, Scheffe method]). A lateral view had significantly higher sensitivity than the Water's view ($P < .001$ [ANOVA, Scheffe method]; Table 5, Figure 3).

In USG, LD had the highest sensitivity ($95.0\% \pm 2.2\%$), followed by D ($84.6\% \pm 3.6\%$) and L ($82.5\% \pm 3.8\%$). However, there was no significant difference among them ($P = .114$ [ANOVA, Scheffe method]; Table 6, Figure 4).

Specificity

The specificity of CT ($94.2\% \pm 2.3\%$) was highest among the 3 methods, followed by USG ($87.4\% \pm 3.3\%$) and PF ($67.8\% \pm 4.7\%$). Computed tomography had significantly higher specificity than USG ($P = .001$ [ANOVA, Scheffe method]). Ultrasonography had significantly higher specificity than PF ($P < .001$ [ANOVA, Scheffe method]; Tables 2-4, Figure 2).

In PF, a lateral view with the Water's view ($75.3\% \pm 4.3\%$) had significantly higher specificity than a lateral view alone ($66.0\% \pm 4.7\%$; $P = .045$ [ANOVA, Scheffe method]). However, there was no significant difference between a lateral view with the Water's view and the Water's view alone ($72.0\% \pm 4.5\%$; $P = .735$ [ANOVA, Scheffe method]) or between the Water's view alone and the lateral view alone ($P = .349$ [ANOVA, Scheffe method]; Table 5, Figure 3).

In USG, LD (100.0%) had significantly higher specificity than L ($80.1\% \pm 4.0\%$; $P = .006$ [ANOVA, Scheffe method]).

Table 6. Diagnostic Performance of Each Method of Ultrasonography for Nasal Bone Fracture.

Method	Author	Year	N	Accuracy	Sensitivity	Specificity	PPV	NPV
Lateral	Thiede ⁴	(2005)	126	88/126	57/82	31/44	57/64	31/47
	Masoomi ¹⁷	(2015)	124	117/124	48/54	69/70	48/49	69/75
	Atiggechi ¹⁵	(2014)	118	97/118	99/118	89/118	107/118	72/118
	Gürkov ⁵	(2008)	80	75/80	63/64	12/16	63/67	12/13
	Lee ¹⁸	(2015)	59	—	44/59	45/59	31/59	50/59
	subtotal		507	377/448	311/377	246/307	306/357	234/312
Dorsum	Thiede ⁴	(2005)	126	72/126	34/74	36/52	35/40	36/56
	Masoomi ¹⁷	(2015)	124	119/124	85/89	34/35	85/86	34/38
	Gürkov ⁵	(2008)	80	78/80	58/59	20/21	58/59	20/21
	Lou ¹²	(2012)	71	69/71	71/71	63/71	68/71	71/71
	subtotal		401	338/401	248/293	153/179	246/256	161/186
Lateral + Dorsum	Javadrashid ⁹	(2011)	40	23/24	38/40	40/40	40/40	38/40
Total			948	738/873 (84.5)	597/710 (84.1)	439/526 (83.5)	592/653 (90.7)	433/538 (80.5)

Abbreviations: N, number of patient, NPV, negative predictive value; PPV, positive predictive value.

Figure 4. Diagnostic performance of ultrasonography. NPV indicates negative predictive value; PPV, positive predictive value. * $P < .05$.

However, there was no significant difference between LD and D ($85.5\% \pm 3.5\%$; $P = .080$ [ANOVA, Scheffe method]) or between D and L ($P = .306$ [ANOVA, Scheffe method]; Table 6, Figure 4).

Positive Predictive Value

The PPVs of USG ($92.0\% \pm 2.7\%$) and CT ($89.3\% \pm 3.1\%$) were higher than the PPV of PF ($82.1\% \pm 3.8\%$; $P < .001$ and $P = .004$, respectively [ANOVA, Scheffe method]). However, there was no significant difference between USG and CT ($P = .4724$ [ANOVA, Scheffe method], Tables 2-4, Figure 2).

In PF, a lateral view with the Water's view ($87.8\% \pm 3.3\%$) had a higher PPV than a lateral view alone ($78.4\% \pm 4.1\%$; $P = .006$ [ANOVA, Scheffe method]). However, there was no significant difference between a lateral view with the Water's view and the Water's view alone ($79.3\% \pm 4.1\%$; $P = .058$ [ANOVA, Scheffe method]), or between the Water's view alone and a lateral view alone ($P = .968$ [ANOVA, Scheffe method]; Table 5, Figure 3).

In USG, LD (100.0%) and D ($96.1\% \pm 1.9\%$) had higher PPVs than L ($85.7\% \pm 3.5\%$; $P = .012$ and $P < .001$, respectively [ANOVA, Scheffe method]). However, there was no significant difference between LD and D ($P = .725$ [ANOVA, Scheffe method]; Table 6, Figure 4).

Negative Predictive Value

The NPVs of USG ($84.4\% \pm 3.6\%$) and CT ($82.0\% \pm 3.9\%$) were higher than the NPV of PF ($51.7\% \pm 5.0\%$; $P < .001$ and $P < .001$, respectively [ANOVA, Scheffe method]). However, there was no significant difference between USG and CT ($P = .856$ [ANOVA, Scheffe method]; Tables 2-4, Figure 2).

In PF, the Water's view ($64.3\% \pm 4.8\%$) had a higher NPV than a lateral view ($46.6\% \pm 5.0\%$), and a lateral view with the Water's view ($45.5\% \pm 58.0\%$; $P < .001$ and $P < .001$, respectively [ANOVA, Scheffe method]). However, there was no significant difference between a lateral view alone and a lateral view with the Water's view ($P = .958$ [ANOVA, Scheffe method]; Table 5, Figure 3).

In USG, LD ($95.0\% \pm 2.2\%$) and D ($86.6\% \pm 3.4\%$) had higher NPVs than L ($75.0\% \pm 4.3\%$; $P = .010$ and $P < .007$, respectively [ANOVA, Scheffe method]). However, there was no significant difference between LD and D ($P = .466$ [ANOVA, Scheffe method]; Table 6, Figure 4).

Discussion

The accuracy of CT ($94.4\% \pm 2.3\%$) was significantly higher ($P < .001$) than that of USG ($85.0\% \pm 3.6\%$). The accuracy of USG was significantly higher ($P < .001$) than that of PF ($67.7\% \pm 4.7\%$; Tables 2-4, Figure 2). Computed tomography ($89.3\% \pm 3.1\%$) and USG ($87.2\% \pm 3.3\%$) had significantly higher sensitivity than PF ($P < .001$ and $P < .001$, respectively). However, there was no significant difference between USG and CT ($P = .492$; Tables 2-4, Figure 2). The specificity of CT ($94.2\% \pm 2.3\%$) was significantly higher ($P = .001$) than that of USG ($87.4\% \pm 3.3\%$). The specificity of USG was significantly higher ($P < .001$) than that of PF ($67.8\% \pm 4.7\%$; Tables 2-4, Figure 2).

It is thought PF should be the first diagnostic tool for detecting an NBF. Ultrasonography or CT can confirm the diagnosis. In performing the reduction of the NBF, CT can serve as a precise map for the surgeons.

For PF, combining a lateral view and the Water's view ($71.8\% \pm 4.5\%$) had significantly higher accuracy than a lateral view alone ($62.4\% \pm 4.8\%$) or the Water's view alone ($61.0\% \pm 4.9\%$; Table 5, Figure 3). The combination of a lateral view and the Water's view ($72.4\% \pm 4.5\%$) likewise had significantly higher sensitivity than a lateral view alone ($58.3\% \pm 4.9\%$) or the Water's view alone ($51.1\% \pm 5.0\%$; Table 5, Figure 3). Thus, a combination of a lateral view and the Water's view is recommended in patients in whom an NBF is suspected.

In USG, there was no significant difference ($P = .300$) in the accuracy among LD ($95.8\% \pm 2.0\%$), L ($84.2\% \pm 3.7\%$), and D ($84.2\% \pm 3.6\%$; Table 6, Figure 4). There was also no significant difference ($P = .300$) in sensitivity among LD ($95.0\% \pm 2.2\%$), L ($82.5\% \pm 3.8\%$), and D ($84.6\% \pm 3.6\%$; Table 6, Figure 4). It is thought that any view will do well when using USG for detecting an NBF.

We compared the diagnostic performance (accuracy, sensitivity, specificity, PPV, and NPV) of each method (PF, USG, and CT) for NBFs. The results of this review may be helpful in choosing the most appropriate diagnostic tool in patients suspected to have an NBF.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This study was supported by a grant from National Research Foundation of Korea (NRF-2017R1A2B4005787).

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