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DIAGNOSTICS

Hoffmann Sign

Clinical Correlation of Neurological Imaging Findings in the Cervical Spine and Brain

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Study Design. Retrospective validity study.

Objective. To investigate the relationship between Hoffmann sign and radiographical evidence of cervical spinal cord compression and brain lesions.

Summary of Background Data. Clinical significance of Hoffmann sign remains controversial with conflicting reports regarding its sensitivity and specificity and its usefulness.

Methods. Patients were divided into 2 groups according to the presence of Hoffmann sign on physical examination. Imaging studies were blindly examined by 2 observers for possible cervical and brain lesions. The sensitivity, specificity, positive predictive value, negative predictive value, as well as accuracy for Hoffmann sign as it relates to cervical spinal cord compression and brain pathology, were calculated.

Results. Of the 91 patients with a positive Hoffmann sign, 32 (35%) showed severe cervical cord compression and/or myelomalacia. Forty-seven of these patients had brain imaging studies, and 5 (10%) had positive findings. There were 80 patients in the negative Hoffmann sign or control group. Twenty-one (27%) of them had severe cervical cord compression and/or myelomalacia. Twenty-three of these control patients underwent neurological imaging of the brain, and 2 (8%) had positive findings. Hoffmann sign was found to have 59% sensitivity, 49% specificity, 35% positive predictive value, and 72% negative predictive value for cervical cord compression. For brain pathology, sensitivity was 71%, specificity 33%, positive predictive value 10%, and negative predictive value 95%.

Conclusion. Hoffmann sign has too low a positive predictive value to be relied upon as a stand-alone physical examination finding and is not a reliable screening tool for solely predicting the presence of cervical spinal cord compression or brain pathology.

Key words: Hoffmann sign, clinical correlation, neurological imaging, cervical spine, brain, sensitivity, specificity, positive predictive value, negative predictive value, accuracy.

Level of Evidence: 2

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Although its origin remains controversial, Hoffmann sign has been in clinical use for more than a century. The sign is attributed to Johann Hoffmann, a pupil of Erb and a Professor of Neurology at Heidelberg, Germany, in the late 19th century. The sign was first reported in 1911 by one of his assistants, Hans Curschmann, who coined the moniker.[1] In response to an inquiry, Dr. Curschmann later wrote[2–4]:

> The finger phenomenon mentioned by me originates from Johann Hoffmann, Professor of Neurology at Heidelberg (died 1919). I learned it while his pupil and assistant from 1901 to 1904. He demonstrated it in his classes and clinics as a sign of hyper-reflexia of the upper extremity. So far as I know he never published it (p. 202).

Hoffmann sign was originally described as follows[2,4]:

> The test is performed by supporting the patient's hand so that it is completely relaxed and the fingers are partially flexed. The middle finger is firmly grasped, partially extended, and the nail snapped by the examiner's thumbnail. The snapping should be done with considerable force, even to the point of causing pain. The sign is present if quick flexion of both the thumb and index finger results. Fingernails other than the middle one are sometimes selected for the snapping.

Currently, Hoffmann sign is used as a test for corticospinal pathway dysfunction. It has also been described as

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the digital reflex, the snapping reflex, Jakobson sign, and Tromner sign.[3,5,6] When present, Hoffmann sign is thought to be indicative of upper motor neuron disease, especially for lesions affecting the cervical spinal cord.[5,7–9] However, the clinical significance of Hoffmann sign remains controversial, with conflicting reports regarding its sensitivity, specificity, and positive and negative predictive values.[4] In a comprehensive review, 3 general views were described by Malanga *et al*.[4,10] The first is that Hoffmann sign is a "pathologic sign, indicating pyramidal tract involvement." The second is that the sign "indicates pyramidal tract involvement but that, owing to its frequent presence in other conditions, its clinical value is doubtful. Finally, Hoffmann sign is "not pathologic of any clinical value." Moreover, Curschmann did not think that Hoffmann sign had pathognomonic significance as a "Babinski of the upper extremity," because he also found the reflex in patients with non-neurological disorders such as hysteria and neurasthenia. He agreed with others that the reflex may occur in healthy patients and in particular nervous individuals without any organic disorder.[11,12] Although several previous studies have examined the relationship between Hoffmann sign and spinal pathology, little is known about the relationship of Hoffmann sign to pathology in the brain.[5,7,8,13] The goals of this study were first to examine the relationship between Hoffmann sign and cervical pathology in symptomatic patients. Second, to evaluate whether patients with Hoffmann sign without radiographical evidence of cervical myelopathy require further workup for a provocative lesion in the brain. Specifically, we asked the question: What percentages of patients with a positive Hoffmann sign without radiographical evidence of cervical pathology have a lesion in the brain that could explain this reflex? Finally, to measure the specificity, sensitivity, and positive and negative predictive values of Hoffmann sign for cervical and brain lesions.

MATERIALS AND METHODS

This was a retrospective analysis of patients with cervical complaints who underwent neurological imaging presenting to a single orthopedic spine surgeon from April 2007 to July 2009. The positive Hoffmann (PH) group consisted of patients who had (1) neck pain or radicular arm complaints at initial presentation, (2) a positive Hoffmann sign, and (3) neurological images of their cervical spine available for review by the examining physician. The control group or negative Hoffmann (NH) consisted of patients who had (1) neck pain or radicular arm complaints at initial presentation, (2) no Hoffmann sign elicited, and (3) cervical spine neurological images available for review by the examining physician. Systemic diseases that may cause hyporeflexia were looked in both the PH and NH groups.

The physical evaluation consisted of a standard history and physical examination. The Hoffmann test was conducted by a single orthopedic spine surgeon. The test was conducted by flicking the long finger from dorsal to volar with the patient's hand supported by the examiner with the wrist in slight dorsiflexion. The test was done with the neck in the neutral position. The test was deemed positive if there was flexion of the ipsilateral thumb and/or the index finger.

All neurological images of the spinal canal were blindly and independently examined by an orthopedic spine surgeon and a neuroradiologist. Only magnetic resonance images or computed tomographic (CT) myelograms were defined as cervical neurological imaging and were reviewed for evidence of spinal cord compression.

Cervical spinal cord compression was defined as complete, anterior and posterior, cerebrospinal fluid effacement and deformation of the cord contour at the level of cerebrospinal fluid effacement, or T2 lengthening within the spinal cord.[7,14] Imaging findings were only considered positive for cervical cord compression if both observers agreed.

The medical records of both sets of patients were retrospectively reviewed for neurological imaging studies of the brain. Only magnetic resonance images and CT scans were defined as brain neurological imaging and were reviewed for evidence of cerebral pathology. All neurological imaging studies of the brain were blindly and independently reviewed by a neurosurgeon and a neuroradiologist.

Criteria for brain pathology were based on lesion location, size, and number. Cerebral lesions must have involved either the cortex or corticospinal tract and must be larger than 2 mm. A study was deemed positive for cerebral pathology if there were more than 5 lesions or a single lesion larger than 1 cm. As with the cervical spine, positive studies were agreed upon by both observers.

The presence or absence of Hoffmann sign, cord compression, and brain pathology, as well as age, sex, and whether or not cervical decompression or brain surgery was performed, were recorded.

The sensitivity, specificity, positive predictive value, negative predictive value, as well as accuracy for Hoffmann sign as it relates to cervical spinal cord compression and brain pathology, were calculated. The disagreement numbers and coefficient of correlation (κ statistic) was also determined comparing the readings of the surgeon and the neuroradiologist in the cervical spine and brain groups. Statistical significance was set at $P = 0.05$. True positive rate (sensitivity) was plotted as the function of the false positive rate (100 − specificity) to obtain the receiver operating characteristic (ROC) curve.

RESULTS

There were 91 patients in the PH group and 80 controls who met our inclusion criteria. Sixty-nine were female (76%) and 22 were male (24%). The average age was 55 years. In the control group, 49 were female (61%) and 31 were male (39%). There was no significant difference in the age, male to female ratio, or presence of cervical spinal cord compression between the groups (Table 1). Systemic disease was present in 28 patients in the PH group and 23 patients in the NH group. There was no statistical difference between 2 groups ($P = 0.64$). The diseases and numbers are summarized in Table 2.

Of the 91 patients with a positive Hoffmann sign, neurological imaging consisted of 85 magnetic resonance images and 6 CT myelograms. Thirty-two (35%) of these patients

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TABLE 1. Descriptive Statistics for 171 Patients Who Composed the Cervical Spine Group

	Positive Hoffmann (n = 91)	Control (n = 80)	*P*
Age, mean ± SD, yr	54.68 ± 12.76	56.51 ± 14.95	0.400
Female:Male	3	1.6	0.062
Stenosis, n (%)	32 (35)	21 (27)	0.761
Surgery, n (%)	21 (23)	10 (12.5)	0.049

showed severe cervical cord compression and/or myelomalacia. Twenty-one (23%) had surgery during the 2-year follow-up.

In the control group, all 80 patients had a magnetic resonance image of the cervical spine available for review. Twenty-one (27%) patients with a negative Hoffmann sign had severe cord compression and/or myelomalacia. Seventeen (21%) patients had cervical spine surgery at 2 years.

TABLE 2. Systemic Diseases in Both the Positive Hoffmann and Negative Hoffmann Groups

	Positive Hoffmann	Negative Hoffmann
No systemic disease	63	56
Endocrinopathy		
Diabetes	9	10
Hypothyroid	14	10
Systemic vasculitis		
Rheumatoid arthritis	1	3
SLE	0	0
PAN	0	0
Renal disease		
Chronic renal failure	3	0
Hematological disease		
Vitamin B_{12} deficiency	1	1
Alcoholism	0	0
Hepatic disease	0	0
Fluid and electrolyte imbalance	0	0
Pregnancy	0	0
Sarcoidosis	0	0
Transplant patients	0	0
	$P = 0.64$	

SLE indicates systemic lupus erythematosus; PAN, poliarteritis nodosa.

TABLE 3. Sensitivity, Specificity, and Positive and Negative Predictive Values for Hoffmann Sign As It Relates to Cervical Spine Pathology

	Spinal Cord Compression	No Compression
Positive Hoffmann	32 (A)	59 (B)
Negative Hoffmann	21 (C)	59 (D)
Sensitivity A/A + C	59.2%	
Specificity D/B + D	49.5%	
Positive predictive value A/A + B	35.1%	
Negative predictive value D/D + C	72.5%	

Forty-seven (52%) of the 91 patients with a positive Hoffmann sign were found to have neurological imaging of the brain (34 magnetic resonance images and 13 plain CT scans) for review. Of these, 5 (10%) had positive findings, 2 had pathology due to leukoencephalopathy, and 3 had pathology due to infarction. However, no patient had brain surgery within 2 years. Of the 5 patients with a positive Hoffmann sign found to have brain pathology, 3 did not have cervical cord compression.

In the control group, 23 patients were found to have neurological imaging of the brain (15 magnetic resonance images and 8 plain CT scans). Of these, 2 patients (8%) had positive findings, both with pathology due to tumor, and a single patient had surgery during the 2 years of the study.

The sensitivity of Hoffmann sign relative to cord compression was found to be 59%, specificity 49%, positive predictive value 35%, and negative predictive value 72% (Table 3). For brain pathology, Hoffmann sign was found to have a sensitivity of 71%, specificity 33%, positive predictive value 10%, and negative predictive value 95% (Table 4).

TABLE 4. Sensitivity, Specificity, and Positive and Negative Predictive Values for Hoffmann Sign As It Relates to Brain Pathology

	Brain Pathology	No Brain Pathology
Positive Hoffmann	5 (A)	42 (B)
Negative Hoffmann	2 (C)	21 (D)
Sensitivity A/A + C	71.4%	
Specificity D/B + D	33.3%	
Positive predictive value A/A + B	10.6%	
Negative predictive value D/D + C	95.4%	

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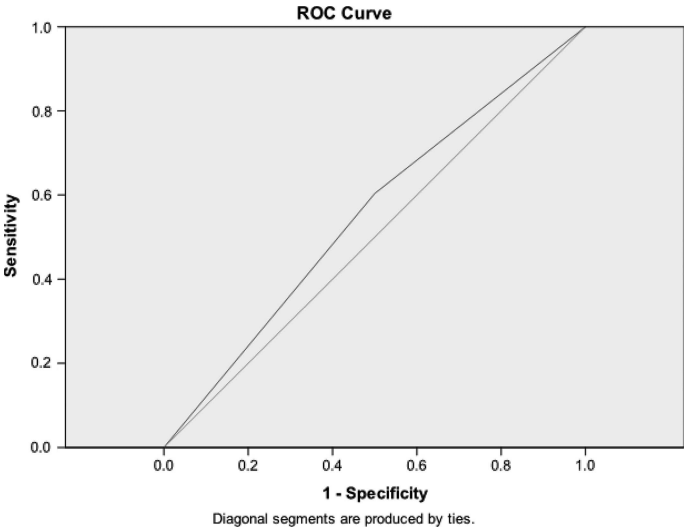

Figure 1. ROC curve for Hoffmann sign for cervical spinal cord compression. ROC indicates receiver operating characteristics.

An ROC curve was obtained for Hoffmann sign as a test for cervical spinal cord compression (Figure 1). The area under the curve was calculated and found to be 0.519, which is not significantly different than chance (P = 0.278; 95% confidence interval [CI], 0.459–0.654). An ROC curve obtained for Hoffmann sign as a test for brain pathology (Figure 2) showed the area under the curve to be 0.519, which, again, was not significantly different from chance (P = 0.872; 95% CI, 0.295–0.743).

Cohen κ values were calculated to determine interobserver reliability of magnetic resonance imaging and CT interpretation. There were 10 of 171 disagreements between the observers for interpretation of spinal imaging and 5 of 70 for brain imaging. For cervical spinal cord compression, Cohen κ showed 0.895 correlation (95% CI, 0.8243–0.9656). For brain pathology, Cohen κ was 0.8592 (95% CI, 0.6687–1.0496).

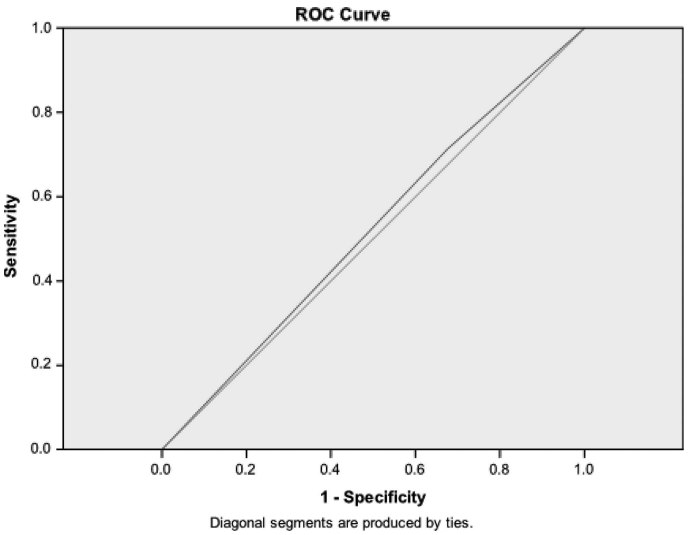

Figure 2. ROC curve of Hoffmann sign for brain pathology. ROC indicates receiver operating characteristics.

DISCUSSION

In this study, we examined the relationship between Hoffmann sign in symptomatic patients and correlative cervical spine and brain imaging. Although Hoffmann sign was more common in patients with cervical spinal cord compression and/or myelomalacia than in controls, we found this sign to have a low positive predictive value of 35% and to be absent in 40% of patients with confirmed cervical pathology. Thus, the presence of Hoffmann sign should not be used as a singular surrogate for the presence of cervical cord compression. Alternatively, the absence of Hoffmann sign does not exclude the presence of significant cervical myelopathy. The sensitivity of Hoffmann sign to detect severe cervical cord compression in our study correlated with findings of the previous studies where sensitivity ranged from 58% to 68% in symptomatic patients.[5,7,13] The specificity of Hoffmann sign was 50% in our study, which is considerably lower than a reported specificity of 84%.[13] One reason for this discrepancy is that prior studies excluded patients with other noncervical spondylotic disorders capable of producing myelopathic signs, making the specificity values artificially higher than they would be in a general population that includes such patients. Our study included such patients and is more likely to accurately represent the true value in the clinical setting. The positive predictive value reported in our study is much lower than what was reported by Glasser *et al*,[5] where radiographs were examined unblinded. However, when the examiner was blinded, the value dropped significantly to 26%, which correlates more closely with our value of 35%. Likewise, the negative predictive value of 73% in our study correlated with the 75% value reported by Glasser *et al* and this value only decreased slightly to 67% when the examiner was blinded.

In our examination of the relationship of Hoffmann sign to causative lesions in the brain, there were no previously reported results for comparison. Although the radiographical criteria for cervical spinal cord compression had been defined previously,[14] the radiographical criteria for a brain lesion that could cause Hoffmann sign needed to be created. This was done with the co-operative efforts of the neuroradiologist (N.W.) and the neurosurgeon (F.H.).

One weakness in this study is that there are no previous studies to validate these criteria. Even so, the purpose of this examination was to elucidate whether significant lesions in the brain are being missed in patients with Hoffmann sign. Only 5 patients in the PH group had lesions in the brain that could cause Hoffmann sign based on our criteria, none of which required surgical intervention. Interestingly, of the 5 patients with Hoffmann sign, 3 did not have radiographical evidence of cervical cord compression and/or myelomalacia. Although these numbers are too low to draw definitive conclusions, they are in keeping with others, including Curschmann, who found that the reflex can be elicited in subjects without a defined central nervous system disorder. This is not to say that Hoffmann reflex should be discarded entirely: we agree with the statement that Hoffmann sign "may be indicative of a pyramidal tract lesion, especially in cases with asymmetric findings and in the presence of other pathological reflexes."[12]

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In conclusion, we feel that Hoffmann sign has too low a positive predictive value to be relied upon as a stand-alone physical examination finding for predicting the presence of cervical spinal cord compression or brain pathology. If used, it should be interpreted in the context of other pathological reflexes and signs. Furthermore, routine brain imaging in patients with a Hoffmann sign without evidence of structural spinal myelopathy is of low yield. Therefore, appropriate clinical judgment should be used in the decision for imaging the brain in patients with a Hoffmann sign without myelopathy.

➢ Key Points

- ❑ The clinical significance of Hoffmann sign remains controversial, with conflicting reports regarding its sensitivity and specificity.
- ❑ For cervical cord spinal lesions, Hoffmann sign was found to have a sensitivity of 59%, specificity 49%, positive predictive value 35%, and negative predictive value 72%.
- ❑ For brain lesions, the sensitivity of Hoffmann sign was 71%, specificity 33%, positive predictive value 10%, and negative predictive value 95%.
- ❑ Hoffmann sign has too low a positive predictive value to be relied upon as a stand-alone physical examination finding and is not a reliable screening tool for predicting the presence of cervical spinal cord compression or brain pathology.

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