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ORIGINAL STUDY

The multidetector CT evaluation of diffuse hyperostosis frontalis interna

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ABSTRACT

OBJECTIVES. Hyperostosis frontalis interna (HFI) is a condition that involves the non-cancerous growth of the inner part of the frontal bone. We investigated diffuse HFI in cranial CT in terms of bone thickness and density.

MATERIAL AND METHODS. The cranial CT images of 154 adult patients with diffuse HFI and 151 adult patients without HFI were included in the study. Bone thickness measurements were performed at vertex, frontal tuberosity and frontal sinus levels in the midline, right and left lateral parts. Density measurements were also performed in the same areas. In the HFI group, measurements were performed at the HFI and non-HFI regions. In the control group, density measurements were also performed.

RESULTS. HFI was detected more in females (96.1%). In diffuse HFI patients, bone thickness values increased at the vertex, frontal tuberosity and frontal sinus levels ($p<0.05$). Bone densities of the HFI parts increased at vertex and frontal tuberosity levels ($p<0.05$). In the HFI group, there were positive correlations between bone thicknesses ($p<0.05$). As bone thicknesses increased, bone density values decreased ($p<0.05$). In older patients, frontal tuberosity and frontal sinus bone densities decreased ($p<0.05$).

CONCLUSION. HFI may be one of the reasons for headaches in females. In the future, it would be better to investigate the relationship between HFI and headaches. The physicians should notice that increased bone thickness may be the sign of the HFI and they should consult with the Radiology Department. When HFI is detected, an endocrinological assessments will also be performed.

KEYWORDS: hyperostosis frontalis interna (HFI), frontal tuberosity, frontal sinus, headache.

INTRODUCTION

Hyperostosis frontalis interna (HFI) is a condition that involves the non-cancerous growth of the inner part of the frontal bone, which is located in the forehead. This condition is most commonly seen in older women, but the cause is unknown. Morgagni-Stewart-Morel syndrome (MSM) is a less understood and reported condition that is characterized by several symptoms, including HFI, obesity, excessive hair growth, and mental disturbances. It is important to note that the presence and severity of HFI should be indicated in radiological reports because it is often a pattern associated with MSM syndrome. It is also worth mentioning that the relationship between MSM syndrome and HFI is mostly based on case reports. Overall, it is important to consider the various symptoms that a patient with MSM syndrome may experience[1].

Hyperostosis frontalis interna is typically an incidental finding on imaging of the head. It can present with symptoms such as headaches, seizures, or dementia that affect the intracranial space. Treatment is generally supportive and there is no specific treatment for this condition. Early diagnosis can help prevent unnecessary testing and assist with supportive care. More research is needed to find the appropriate treatment for this rare condition. The etiology of HFI is mostly unknown and it can be divided into syndromic and non-syndromic forms. Non-syndromic forms are typically found incidentally in postmenopausal women. Syndromic forms are associated with pathologies such as Morgagni syndrome, Stewart-Morel syndrome,

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and Troell-Junet syndrome, which have endocrine and obesity abnormalities. Memory loss and chronic headaches are often seen in patients with HFI. Laboratory findings can be normal if there are no endocrine abnormalities. The diagnosis is made using direct radiography and CT scans. HFI is an important cause of chronic headaches in elderly women that are often difficult to diagnose, and the cause is unknown. In this respect, HFI is an incidental finding on cranial imaging, and can present with different symptoms such as headaches, seizures, and dementia. It can also cause pressure symptoms on cerebral structures and vascular structures[2].

HFI is classified into four groups based on severity according to Hershkovitz's morphological and histopathological findings[3]. The Hershkovitz classification was expanded to include five groups based on a post-mortem study that evaluated the severity of the disease in 2011 and identified hyperostotic findings in the falx cerebri[4,5]:

- Type A: A small thickening of the endocranial frontal bone, measuring less than 10 mm in diameter;
- Type B: A small, nodule-like formation of bone covering less than 25% of the frontal bone;
- Type C: A nodule-like formation of bone covering half of the frontal bone;
- Type D: A continuous, nodule-like formation of bone involving more than half of the frontal endocranium;
- Type E: Severe internal frontal hyperostosis, reaching into surrounding soft tissue.

In the present study, we investigated HFI in cranial CT scans. We evaluated bone thickness in diffuse HFI in 3 anatomical locations, namely at the vertex level, frontal tuberosity level and frontal sinus level. Moreover, the density of the bones in HFI areas and non-HFI areas was also evaluated.

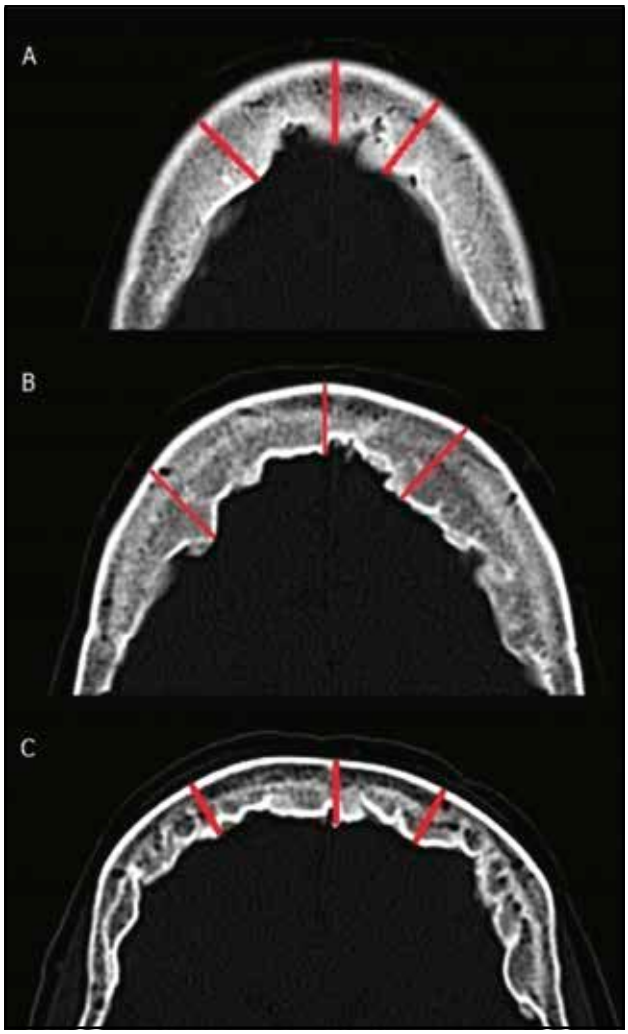

Figure 1. Cranial CT scan, axial plane. Cranial bone thickness measurements were performed at 3 levels of the frontal bone. **A:** Vertex level, **B:** Frontal tuberosity level, **C:** Frontal sinus level.

MATERIAL AND METHODS

This retrospective study was conducted at Kırıkkale University, Faculty of Medicine, involving the Radiology and Otorhinolaryngology Departments. Cranial Computed Tomography (CT) scans were retrieved from the database of the Radiology Department. The study was approved by Non-invasive Research Ethics Committee of Kırıkkale University (Date: 25.03.2021, Number: 2021.03.01). The study was performed according to the principles of the Declaration of Helsinki.

Subjects

The cranial CT images of 154 adult patients (6 males and 148 females) with diffuse HFI[3] were retrieved from the Hospital PACS system from January 2017 to January 2022. The mean age of the HFI group was 69.33±14.34 years (ranging from 25 to 97 years).

The control group consisted of the cranial CT images of the 151 adult patients without HFI (8 males and 143 females). The mean age of the control group was

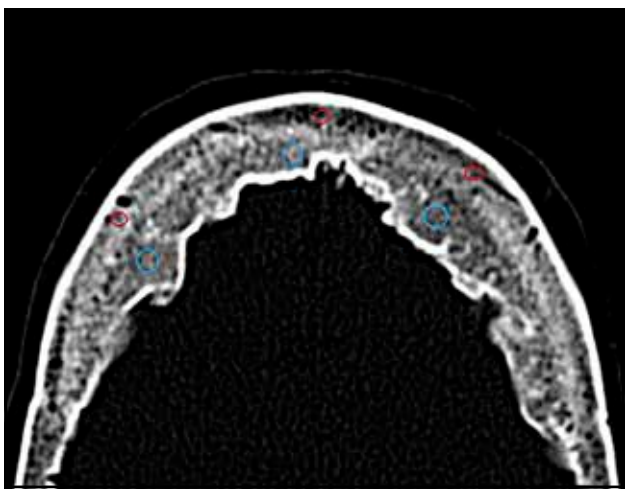

Figure 2. Cranial CT scan, axial plane. Density of the frontal bone. Red circle: Density was measured in the non-HFI part of the frontal bone. Blue circle: Density was measured in the HFI part of the frontal bone.

66.21±13.60 years (ranging from 38 to 89 years).

Patients with lobular HFI, a history of trauma, benign or malign cranial tumor, history of surgery to frontal sinus, CSF leakage, or diagnosed with neurological disorders such as epilepsy, Parkinson's disease, Alzheimer's disease, were not included in the study.

Cranial CT scan

All the images were acquired through standard cranial CT scans conducted with the patient lying on their back, without the use of contrast agents or sedation, using the following parameters: tube voltage = 120 kV, effective mAs = 375, slice thickness = 3.00 mm, field of view (FOV) = 250 mm, image matrix = 512×512. The scans were obtained with a 64-slice CT scanner (MSCT; Brilliance 64, Philips Medical System, Best, the Netherlands) and then transferred to a commercial workstation. Bone algorithms were used to reconstruct the raw data, and the assessment was conducted on the axial plane within the workstation.

Measurements

1. **Cranial bone thickness** measurements were performed at 3 levels of the frontal bone[6]:
   - **Vertex level:** Measurements were performed at midline, right (R) lateral and left (L) lateral (Figure 1A).
   - **Frontal tuberosity level (mm):** Measurements were performed at midline, R lateral and L lateral (Figure 1B).
   - **Frontal sinus level (mm):** Measurements were performed at midline, R lateral and L lateral (Figure 1C).
1. **Density of the frontal bone:** Measurements were performed using a Region of interest (ROI) with the diameter of 2-4 mm and area of 3-10 mm^2 (Figure 2).
   - **Vertex density (HU)**: In the HFI group, vertex density was measured in the non-HFI part and HFI part of the frontal bone. In the control group, as HFI was not present, density measurements were performed from the vertex (as non-HFI measurements).
   - **Frontal tuberosity density (HU)**: In the HFI group, frontal tuberosity density was measured in the non-HFI part and HFI part of the frontal bone. In the control group, as HFI was not present, density measurements were performed from the frontal tuberosity (as non-HFI measurements).
   - **Frontal sinus density (HU)**: In the HFI group, frontal sinus density was measured in the non-HFI part and HFI part of the frontal bone. In the control group, as HFI was not present, density measurements were performed from the frontal sinus (as non-HFI measurements).

Statistical analysis

The data were analyzed using SPSS for Windows 21.0 software (SPSS, INC, an IBM Company, Chicago, Illinois). The Chi-square test, Mann-Whitney U test, independent samples t-test, paired samples t-test and Spearman's correlation rho efficient test were used.

A p-value < 0.05 was considered statistically significant.

RESULTS

In the HFI group, there were 6 (3.9%) males and 148 (96.1%) females. In the control group, there were 8 (5.3%) males and 143 (94.7%) females (p=0.559, X2: 0.342). There were no significant differences between the ages of the HFI group and control group (p>0.05) (Table 1).

Cranial bone thickness and density measurement results in the HFI and control groups are shown in Table 1.

Thickness measurements

Vertex level

In the HFI group, cranial bone thickness values at the midline (12.88±3.43 mm), right (R) lateral (15.94±4.75 mm) and left (L) lateral (15.48±4.66 mm) were significantly higher than those in the control group (8.01±2.04 mm, 8.69±1.96 mm and 8.64±1.97 mm respectively) (p<0.05) (Table 1).

Frontal tuberosity level

In the HFI group, frontal tuberosity level bone thickness values at the midline (11.20±2.84 mm), R lateral (15.19±3.63 mm) and L lateral (15.60±4.00 mm) were significantly higher than those in the control group (7.12±1.70 mm, 6.37±1.77 mm and 6.52±1.81 mm respectively) (p<0.05) (Table 1).

Frontal sinus level

In the HFI group, frontal sinus level bone thickness values at the midline (11.00±2.30 mm), R lateral (10.28±3.43 mm) and L lateral (10.55±3.64 mm) were significantly higher than those in the control group (7.21±1.80 mm, 4.25±1.29 mm and 4.31±1.30 mm respectively) (p<0.05) (Table 1).

Density measurements

In the HFI group, HFI part density and in the control group, the density of related anatomical parts was taken into the analysis. In the HFI group, HFI density values were higher if HFI was present in that place. If there was no HFI in that anatomical region, HFI density values were not determined. Because of that, there are missing values.

Vertex density

Vertex densities of the HFI group (1064.56±244.33 HU) were significantly higher than those in the control group (837.06±214.25 HU) (p<0.05) (Table 1). There were no significant differences between the densities of the non-HFI parts of the HFI group and control group (p>0.05) (Table 1).

In the HFI group, vertex densities of the HFI parts (1064.56±244.33 HU) were significantly higher than those of the non-HFI parts (801.67±204.15 HU) (p<0.05) (Table 1).

Frontal tuberosity density

Frontal tuberosity densities of the HFI group

Table 1. Cranial bone thickness and density measurement results in the HFI and control groups.

		HFI group (n=154)			HFI group (n=154)			P
		Mean	Median	Std. Dev.	Mean	Median	Std. Dev.	
Age		69.33	72.50	14.34	66.21	66.00	13.60	0.052**
Thickness measurements								
Vertex level (mm)	Midline	12.88	12.22	3.43	8.01	7.97	2.04	0.000*
	R lateral	15.94	15.28	4.75	8.69	8.69	1.96	0.000*
	L lateral	15.48	15.33	4.66	8.64	8.30	1.97	0.000*
Frontal tuberosity level (mm)	Midline	11.20	11.24	2.84	7.12	7.10	1.70	0.000*
	R lateral	15.19	14.99	3.63	6.37	5.98	1.77	0.000*
	L lateral	15.60	15.41	4.00	6.52	6.21	1.81	0.000*
Frontal sinus level (mm)	Midline	11.00	10.92	2.30	7.21	6.90	1.80	0.000**
	R lateral	10.28	9.80	3.43	4.25	4.17	1.29	0.000*
	L lateral	10.55	10.06	3.64	4.31	4.17	1.30	0.000*
Density								
Vertex density non-HFI part		801.67	803.50	204.15	837.06	865.00	214.25	0.141**
Vertex density HFI part*** (for HFI group, n=110 ¶)		1064.56	1107.00	244.33	837.06	865.00	214.25	0.000**
P****			0.000					
Frontal tuberosity density non-HFI part		789.09	797.50	227.77	836.11	838.00	238.16	0.079**
Frontal tuberosity density HFI part*** (For HFI group, n=152)		940.84	955.50	280.45	836.11	838.00	238.16	0.001**
P****			0.000					
Frontal sinus density non-HFI part		674.03	662.00	212.86	730.87	740.00	220.50	0.023**
Frontal sinus density HFI part*** (For HFI group, n=141 ¶)		736.48	694.00	281.09	730.87	740.00	220.50	0.849**
P****			0.002					

HFI - hyperostosis frontalis interna; R - right; L – left; ¶: This measurement can be performed in these numbered patients.
*p value shows the results of Mann-Whitney U Test
**p value shows the results of independent samples t-test
***In the HFI group, HFI part density and in the control group, the densities of related anatomical parts were taken into the analysis. In the HFI group, HFI density values were higher if HFI was present in that place. If there was no HFI in that anatomical region, HIF density values were not determined. Because of that, there are missing values.
****p value shows the results of paired samples t-test

(940.84±280.45 HU) were significantly higher than those in the control group (836.11±238.16 HU) ($p<0.05$) (Table 1). There were no significant differences between the densities of the non-HFI parts of the HFI group and control group ($p>0.05$) (Table 1).

In the HFI group, frontal tuberosity densities of the HFI parts (940.84±280.45 HU) were significantly higher than those of the non-HFI parts (789.09±227.77 HU) ($p<0.05$) (Table 1).

Frontal sinus density

For the frontal sinus density, there were no significant differences between the densities of the HFI parts of the HFI group and control group ($p>0.05$) (Table 1). However, the density of the non-HFI parts of the HFI group were significantly lower than those in the control group ($p>0.05$) (Table 1).

In the HFI group, frontal sinus densities of the HFI parts (736.48±281.09 HU) were significantly higher than those of the non-HFI parts (674.03±212.86 HU) ($p<0.05$) (Table 1).

Correlation test results in the HFI group

There were positive correlations between bone thickness values at the vertex (midline, R lateral and L lateral), frontal tuberosity level (midline, R lateral and L lateral) and frontal sinus level (midline, R lateral and L lateral) ($p<0.05$) (Table 2). These results showed that these mea-

Table 2. Correlation test results in the HFI group.

			Vertex level (mm)			Frontal tuberosity level (mm)			Frontal sinus level (mm)		
			Midline	R lateral	L lateral	Midline	R lateral	L lateral	Midline	R lateral	L lateral
Vertex level (mm)	Midline	r		0.628	0.650	0.654	0.506	0.538	0.460	0.304	0.313
		p		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	R lateral	r	0.628		0.820	0.639	0.671	0.643	0.425	0.389	0.392
		p	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000
	L lateral	r	0.650	0.820		0.614	0.641	0.645	0.389	0.366	0.321
		p	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000
Frontal tuberosity level (mm)	Midline	r	0.654	0.639	0.614		0.553	0.565	0.644	0.380	0.381
		p	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
	R lateral	r	0.506	0.671	0.641	0.553		0.811	0.465	0.568	0.505
		p	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000
	L lateral	r	0.538	0.643	0.645	0.565	0.811		0.413	0.503	0.496
		p	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000
Frontal sinus level (mm)	Midline	r	0.460	0.425	0.389	0.644	0.465	0.413		0.527	0.494
		p	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000
	R lateral	r	0.304	0.389	0.366	0.380	0.568	0.503	0.527		0.851
		p	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000
	L lateral	r	0.313	0.392	0.321	0.381	0.505	0.496	0.494	0.851	
		p	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
Vertex density	Non-HFI part	r	-0.314	-0.115	-0.137	-0.225	-0.133	-0.199	-0.069	-0.073	-0.089
		p	0.000	0.154	0.089	0.005	0.100	0.014	0.394	0.365	0.272
	HFI part (n=110)	r	-0.254	-0.050	-0.138	-0.232	-0.121	-0.167	-0.075	0.028	0.030
		p	0.008	0.603	0.151	0.015	0.209	0.080	0.434	0.768	0.754
Frontal tuberosity density	Non-HFI part	r	-0.368	-0.192	-0.161	-0.328	-0.199	-0.273	-0.166	-0.150	-0.121
		p	0.000	0.017	0.046	0.000	0.013	0.001	0.040	0.063	0.134
	HFI part (n=152)	r	-0.174	-0.219	-0.236	-0.239	-0.281	-0.327	-0.215	-0.247	-0.162
		p	0.032	0.007	0.003	0.003	0.000	0.000	0.008	0.002	0.046
Frontal sinus density	Non-HFI part	r	-0.276	-0.118	-0.088	-0.210	-0.069	-0.107	-0.128	-0.144	-0.103
		p	0.001	0.146	0.280	0.009	0.396	0.188	0.113	0.075	0.202
	HFI part (n=141)	r	-0.122	-0.117	-0.119	-0.203	-0.205	-0.241	-0.113	-0.219	-0.177
		p	0.149	0.168	0.159	0.016	0.015	0.004	0.183	0.009	0.036
Age		r	0.070	0.019	-0.037	0.074	0.035	0.140	0.082	0.175	0.149
		p	0.388	0.818	0.646	0.359	0.666	0.083	0.314	0.030	0.066
Gender (Code 1: male, Code 2: Female)		r	-0.111	0.029	0.009	-0.013	-0.113	-0.097	0.062	-0.025	-0.015
		p	0.172	0.720	0.915	0.871	0.162	0.230	0.446	0.763	0.849

HFI - hyperostosis frontalis interna; R - right; L – left; ¶: This measurement can be performed in these numbered patients. *p value shows the results of Spearman's correlation rho efficient test

surement results increased or decreased altogether.

There were negative correlations between bone thickness and bone density. As bone thickness increased, density values at the HFI and non-HFI parts decreased in vertex, frontal tuberosity and frontal sinus levels ($p<0.05$) (Table 2). These results showed that in bone thickness increased regions, density values were lower.

In older patients, frontal sinus R lateral thickness values increased ($p<0.05$) (Table 2), meaning that the bone thickness in the measured area increases with age.

In older patients, frontal tuberosity non-HFI ($p=0.016$, $r = - 0.194$) and HFI densities ($p=0.004$, $r = - 0.235$) de-

creased; frontal sinus non-HFI (p=0.000, r = - 0.317) and HFI densities (p=0.000, r = - 0.332) decreased. These findings indicate that bone density in the measured areas decreased with increasing age.

There were no significant correlations between gender and bone thickness and density values (p<0.05).

DISCUSSIONS

Hyperostosis frontalis interna is a medical condition that involves the thickening of the inner side of the frontal bone in the skull. This bone growth is benign, which means it is not cancerous, and is generally not a significant clinical issue. Many people with HFI may not even be aware that they have it, as it does not typically cause any symptoms. This condition is more common in women than men and is often seen in older women who are nearing menopause. It is worth noting that the bone growth associated with HFI is usually not a cause for concern and does not require treatment[3,7].

Thickened bone usually affects the frontal bones, but sometimes can include the parietal bones of the skull. The thickened area is usually bilateral and symmetrical. Although not the whole bone, it can focus on only a part of it or be diffuse by affecting a large part of it. Overgrown parts can be a bit flat and even flat or nodular in appearance[3,8].

In the present study, we evaluated bone thickness in diffuse HFI in 3 anatomical locations, namely at the vertex level, frontal tuberosity level and frontal sinus level. Moreover, densities of the bones in HFI areas and non-HFI areas were also evaluated. Our results showed that HFI was detected mainly in females (96.1%).

The exact cause of HFI is unknown, but it appears to occur more frequently in women who are near menopause, which suggests that hormones like estrogen may play a role in its development. Since the bone thickening associated with HFI is benign and does not pose a threat to the patient, treatment is not necessary. Instead, individual symptoms are addressed as needed. It is worth noting that HFI is not a life-threatening condition and does not affect a person's lifespan. People with HFI can expect to have the same lifespan as those who are healthy[5].

The fact that HFI is more commonly seen in women suggests that estrogen is an important factor in the development of HFI[9]. Hormones (such as estrogen) trigger the dura; however, exactly how this happens is not known. In animal experiments, it has been reported that estrogen receptors are located in the calvarium and dura, and that estrogen plays an important role in the vascular tissue of the meninges[9]. Here, the presence of vascularization extending from the dura to the bone may explain the pathogenesis of HFI. Thus, it can be said that the frontal bone is particularly affected by the specific characteristics of the neighboring dura.

In the present study, in the HFI group, bone thickness values at the vertex, frontal tuberosity and frontal sinus levels in the midline, R lateral and L lateral were significantly higher than those in the control group.

HFI arises from the expansion of the internal component of the diploe distance[10]. Hyperostosis frontalis interna is an abnormality of the tabula interna. On the inner surface of the tabula interna, typically smooth, round bone protrusions covered with dura and protruding into the cranial cavity, thickening, and lobulation are seen. These protrusions are typically less than 1 cm in thickness[11]. Sometimes, it can be seen as fronto-parietal hyperostosis, which can mimic metastasis. It can involve both the frontal and parietal bones[12].

In HFI, there can also be thickening of other cranial bones[7,13]. However, it is assumed that HFI only affects the cranial bones and that the rest of the skeleton is normal[13]. The etiology is unclear, but prolonged or increased estrogen stimulation during the reproductive period is considered responsible, particularly because it is commonly seen in postmenopausal women[3]. An increase in total porosity of the table interna was observed. In conclusion, an increase in porosity and vascularity of the frontal bone was observed. Some researchers argue that modern lifestyles increase estrogen stimulation and that this leads to the development of HFI[4,14]. According to Hershkovitz et al.[3], in the pathogenesis, estrogen cells induce a series of events that result in the expansion of the tabula interna diploe distance and the cranial cavity.

In our study, except the frontal sinus density, densities of the HFI parts were significantly higher than in the control group; the same observation for the non-HFI parts of the HFI group in the vertex and frontal tuberosity. Vertex densities of the HFI group (1064.56±244.33 HU) were significantly higher than those in the control group (837.06±214.25 HU). In the HFI group, vertex densities of the HFI parts (1064.56±244.33 HU) were significantly higher than those in the non-HFI parts (801.67±204.15 HU). Frontal tuberosity densities of the HFI group (940.84±280.45 HU) were significantly higher than those in the control group (836.11±238.16 HU). In the HFI group, frontal tuberosity densities of the HFI parts (940.84±280.45 HU) were significantly higher than those in the non-HFI parts (789.09±227.77 HU). For the frontal sinus density, there were no significant differences between the densities of the HFI parts of the HFI group and the control group.

In the HFI group, correlation tests showed that there were positive correlations between bone thickness values at the vertex, frontal tuberosity and frontal sinus levels. As bone thickness increased, density values at the HFI and non-HFI parts decreased in vertex, frontal tuberosity and frontal sinus levels. In older patients, frontal sinus R lateral thickness values increased. In older patients, frontal tuberosity and frontal sinus HFI and non-HFI densities decreased.

HFI can cause a variety of symptoms, including frontal headaches, mental disturbance, depression, weakness, obesity, fatigue, dizziness, and facial paralysis. These symptoms are often seen in other conditions as well, so it is important to consider a differential diagnosis to rule out conditions like Paget's disease, fibrous dysplasia, and acromegaly. The only way to confirm a diagnosis of HFI is through a radiographic image that clearly shows thickened bone. HFI is often discovered accidentally during treatment for another condition, which makes it difficult to determine how many people are affected by this condition[3,13,15].

In some cases, HFI may be part of a larger medical condition called Morgagni syndrome. This is an endocrine disorder characterized by HFI, diabetes, and hyperparathyroidism. Symptoms of Morgagni syndrome may include hirsutism, menstrual problems, and seizures[4].

In females, HFI is linked to an increase in porosity within the diploe and internal tabula of the frontal bone compared to a healthy control group. This condition is more common in women than men, and the severity tends to worsen with age, with the highest levels typically occurring during the postmenopausal period[3,7].

HFI is often overlooked, but it can have significant clinical implications. In the past, it was believed to only occur as part of a syndrome, such as "Morgagni-Stewart-Morel-Moore (obesity, neuropsychiatric symptoms, headache)", "Troell-Junet (acromegaly, toxic goiter, diabetes mellitus)", "Frolich (obesity, growth retardation, pituitary hypocrinism)", or "Klippel-Trenaunay-Weber (varicose veins, port-wine stain, overgrowth of bone and soft tissue)". However, recent research has demonstrated that HFI can also occur on its own, independent of these syndromes[5,13].

HFI can lead to neurological problems by putting pressure on the cerebral cortex[14]. It has also been linked to cognitive slowing, mood disorders, epilepsy, dementia, schizoaffective disorders, headaches, and increased pressure within the skull[3,13,15]. Some research has also suggested a connection between HFI and Parkinson's and Alzheimer's disease[14,16].

Govsa and colleagues' study[17] investigated the increased thickness of the inner surface of the frontal bone (ISFB) in relation to its potential to exert pressure on brain tissue and changes in bone marrow structure. The thickening of bone can put pressure on the dura mater and brain tissue in both the nodular and diffuse forms of HFI. The presence and frequency of bone thickening on the inner surface of the frontal bone have largely been linked to hormonal disorders such as pregnancy-related osteophytes, acromegaly, Paget's disease, osteoid osteoma, lenticulosisossea, or senile hyperostosis. This study aims to determine whether the presence of bone thickening or displacement of blood vessels in these areas will affect the surgical intervention process. The increase in bone thickening and vascular vessel formation can alter the surgical process because these formations are close to brain tissue and serve important functions in the brain region. The thickening of bone on the inner surface of the frontal bone can cause pressure on the cerebral gyri. The changes can be isolated or widespread and their borders can be distinct or indistinct.

CONCLUSIONS

In conclusion, hyperostosis frontalis interna was detected more in females. In diffuse HFI patients, bone thickness values increased at the vertex, frontal tuberosity, and frontal sinus levels. Bone densities of the HFI parts increased at vertex and frontal tuberosity levels. In the HFI group, there were positive correlations between bone thicknesses. As bone thicknesses increased, bone density values decreased. In older patients', frontal tuberosity and frontal sinus bone densities decreased.

HFI may be one of the reasons for headaches in females.

In the future, it would be better to investigate the relationship between HFI and headaches. The physicians should notice that increased bone thickness may be the sign of the HFI and they should consult with the Radiology Department. When HFI is detected, an endocrinological assessments will also be performed.

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