

FREQUENCY AND PREVALENCE OF AGE AND GENDER-RELATED INTRACRANIAL CALCIFICATIONS WITH ASSOCIATED DISORDERS IN PATIENTS ON COMPUTED TOMOGRAPHY SCAN

Zarwa Gohar¹, Dr. Muhammad Adnan Hafeez^{*2}

¹MS Allied Health Sciences, Faculty of Allied Health Sciences, The Superior University, Lahore, Pakistan

^{*2}Faculty of Allied Health Sciences, The Superior University, Lahore, Pakistan

^{*2}adnan.hafeez@superior.edu.pk

DOI: <https://doi.org/10.5281/zenodo.22703017>

Keywords

intracranial calcification, computed tomography, age, gender, physiological calcification, pathological calcification, associated disorders

Article History

Received: 01 June 2026

Accepted: 23 August 2026

Published: 11 September 2026

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Corresponding Author: *

Dr. Muhammad Adnan Hafeez

Abstract

Background: Intracranial calcifications are common findings on non-contrast computed tomography (CT) and may represent physiological or pathological processes. Interpretation requires consideration of age, sex, anatomical location, morphology, pattern, size, associated disorders, and accompanying CT abnormalities. **Objective:** To determine the frequency and prevalence of age and gender-related intracranial calcifications and identify associated disorders among patients with CT-confirmed intracranial calcifications. **Methods:** This descriptive cross-sectional observational study included 169 patients aged 10–85 years with intracranial calcifications on non-contrast CT brain examinations obtained from Jinnah Hospital and Sharif Medical Complex, Lahore, and Sehar Hospital, Okara. Non-probability convenience sampling was used. Demographic, clinical, and radiological variables were analyzed in SPSS version 27.0 using frequencies, percentages, cross-tabulations, and Pearson's chi-square tests, with $p < 0.05$ considered statistically significant. **Results:** Of 169 patients, 95 (56.2%) were female and 74 (43.8%) were male; the 41–55-year group was largest (24.3%). Physiological/age-related calcifications accounted for 56.8% and pathological calcifications for 43.2%. The leading imaging features were pineal location (24.3%), smooth morphology (56.2%), circular peripheral pattern (20.1%), and microcalcification (51.5%). Hypertension (25.4%), diabetes mellitus (18.9%), and infectious disorders (14.8%) were the most frequent associated disorders. Infarct/stroke was the most common associated CT finding (26.6%), whereas 36.7% had no additional CT finding. Age group was significantly associated with congenital disorders ($p = 0.044$), infectious disorders ($p < 0.001$), and other disorders ($p = 0.033$); the association with hypertension was borderline but not statistically significant ($p = 0.058$). **Conclusion:** Physiological calcifications predominated, although pathological calcifications represented more than two-fifths of cases. Non-contrast CT effectively characterized calcification patterns and associated abnormalities.

1. INTRODUCTION

Intracranial calcifications (ICs) are common computed tomography (CT) findings that may represent physiological or pathological processes involving the brain parenchyma, vessels, ventricles, meninges, and deep gray nuclei. CT is the preferred imaging modality because it accurately detects and characterizes calcium according to its location, density, morphology, and distribution (1,2).

Calcification occurs through two principal mechanisms. Dystrophic calcification develops in damaged or necrotic tissue following infection, ischemia, hemorrhage, inflammation, or neoplasia despite normal calcium metabolism. Metastatic calcification results from disturbed calcium-phosphate homeostasis and is commonly associated with endocrine, metabolic, or renal disorders (18). Compared with magnetic resonance imaging, CT provides more reliable differentiation of calcium from hemorrhage, while multidetector CT improves anatomical localization and morphological assessment (2,22).

Physiological calcifications are generally asymptomatic, increase with age, and commonly affect the pineal gland, choroid plexus, falx cerebri, tentorium cerebelli, and occasionally the basal ganglia (3–5). Small, symmetrical, and smoothly marginated deposits at typical sites usually indicate benign age-related changes. However, unusually large, irregular, asymmetric, or early-onset calcifications may require further assessment (14,15,26).

Pathological calcifications may result from congenital, infectious, vascular, inflammatory, metabolic, toxic, or neoplastic disorders (6–12). Symmetrical bilateral deposits may suggest metabolic, endocrine, or genetic disease, whereas focal or asymmetric calcifications may indicate infection, vascular injury, or neoplasia (7,18,19). Hypoparathyroidism, chronic kidney disease, and primary familial brain calcification commonly produce bilateral deposits involving the basal ganglia and related structures (7,8,40).

Infectious calcifications remain important in younger populations and regions where neuroinfection is endemic. Congenital infections may cause periventricular or diffuse calcifications, while calcified neurocysticercosis may act as an epileptogenic focus (9,12,32,33). Characteristic

calcification patterns may also occur in Sturge-Weber syndrome and tumours such as oligodendroglioma, meningioma, craniopharyngioma, and ependymoma (10,34–37).

Age is the most consistent demographic determinant of physiological calcification, whereas reported gender differences vary according to anatomical site, disease, and population (5,6,13). In older adults, vascular calcifications may coexist with hypertension, diabetes mellitus, chronic kidney disease, stroke, and cognitive impairment, reflecting cumulative vascular burden (10,11,38,39). In younger patients, calcification more often warrants investigation for infectious, congenital, metabolic, or genetic causes.

Although many physiological calcifications are incidental, pathological deposits may be associated with seizures, neurological deficits, movement disorders, developmental delay, cognitive impairment, or cerebrovascular disease (17,23). Accurate interpretation requires consideration of age, clinical presentation, location, morphology, pattern, size, symmetry, and associated CT findings. Structured reporting may therefore improve diagnostic accuracy and guide further clinical evaluation (14,24–26).

Local evidence regarding the demographic and radiological distribution of intracranial calcifications remains limited. This study therefore aimed to describe the age- and gender-related frequency and distribution of intracranial calcifications and identify associated disorders among patients with calcifications detected on CT brain imaging.

Methodology**Research design**

This was a descriptive cross-sectional observational study based on previously acquired non-contrast CT brain examinations and available clinical records. The design enabled assessment of the demographic, clinical, and radiological distribution of intracranial calcifications within the study cohort without introducing an intervention or additional radiation exposure.

Clinical settings

The study was conducted in the radiology departments of Jinnah Hospital and Sharif Medical Complex, Lahore, and Sehar Hospital, Okara. Non-

contrast CT brain images, radiology reports, and relevant clinical records were reviewed using a structured data collection proforma.

Sample size

The sample size was calculated using Cochran's formula:

$$n = Z^2 \times p \times (1 - p) / e^2$$

$Z=1.96$ (for 95% confidence level); $p=0.5$; $q=1-p=0.5$; $e=0.075$.

$$n_0 = (1.96^2 \times 0.50 \times 0.50) / 0.075^2 = (3.8416 \times 0.25) / 0.005625 \approx 169$$

Therefore, the calculated sample size was 169 patients.

Sampling technique

A non-probability convenience sampling technique was used. Consecutive available records that met the eligibility criteria during the defined study period were included until the required sample of 169 patients was achieved.

Duration of study

The study was conducted over four months, including data collection, review of CT findings, data entry, and analysis.

Selection criteria**Inclusion criteria**

- Patients aged 10–85 years.
- Patients of both sexes.
- Non-contrast CT brain scans demonstrating intracranial calcification.
- Patients with physiological or pathological intracranial calcifications that could be adequately characterized on CT.

Exclusion criteria

- Pregnant patients.
- Patients with a history of neurosurgical intervention affecting CT interpretation.
- Records with indeterminate hyperdensity in which calcification could not be distinguished reliably from hemorrhage or another material.
- CT scans of inadequate quality or with indeterminate calcific findings.

Ethical considerations

Ethical approval was obtained from the Ethical Review Committee (ERC) of Superior University,

Lahore before commencement of the study. Administrative permission was also obtained from the participating hospitals for access to relevant CT brain examinations and clinical records. The study was conducted in accordance with institutional ethical requirements and the principles of confidentiality, privacy, and responsible use of patient data.

This observational study used previously acquired non-contrast CT brain scans and available medical records and did not require additional imaging, invasive procedures, or alteration of standard patient care. Consent procedures and access to records were handled in accordance with the conditions approved by the relevant ethics committee and participating institutions.

Patient confidentiality and privacy were maintained throughout the study. Personal identifiers were excluded from the analytical dataset, and study records were coded to preserve anonymity during data entry, analysis, and presentation. Electronic data were stored in password-protected files accessible only to the principal investigator and research supervisor, while printed material was kept securely.

The collected data were used solely for academic and research purposes and were reported in aggregate form without identifying individual patients. Scientific integrity, confidentiality, and transparency were maintained throughout data collection, analysis, interpretation, and reporting.

Data collection procedure

After ethical and administrative approvals, previously acquired non-contrast CT brain examinations and available clinical records were reviewed at the participating radiology departments. Each record was screened against the predefined eligibility criteria, assigned a study identification code, and entered without personal identifiers.

For each eligible examination, age, gender, hospital site, CT indication, and documented associated disorders were recorded. Age was categorized as 10–25, 26–40, 41–55, 56–70, or 71–85 years. The indication for CT was classified as headache, seizures, trauma, stroke/neurological deficit, or another documented reason.

Associated disorders were abstracted from the available clinical record and classified as

hypertension, diabetes mellitus, hypoparathyroidism, chronic kidney disease, congenital disorder, infectious disorder, neoplasm, or other disorder. These variables represented documented coexistence and were not assumed to be the cause of calcification.

CT calcifications were systematically classified as physiological/age-related or pathological. The predominant location was recorded as pineal gland, choroid plexus, cerebral cortex, falx cerebri/tentorium cerebelli, basal ganglia, ventricular, or other. Morphology was categorized as smooth or irregular; pattern as punctate, diffuse punctate, linear, curvilinear, compound, or circular peripheral; and size as microcalcification or macrocalcification according to the study's predefined radiological criteria.

Associated CT findings were recorded as hydrocephalus, mass/tumour, infarct/stroke, cerebral atrophy, other finding, or no associated CT finding. The predominant category was entered where variables were mutually exclusive. Completed proformas were checked for completeness, internal consistency, and agreement with the source images/report before anonymized data entry.

Data analysis

All study variables were coded and entered into Statistical Package for the Social Sciences (SPSS)

version 27.0. Data were checked for completeness, consistency, and entry errors before analysis. Categorical variables, including age group, gender, calcification morphology, affected cerebral lobe, radiological pattern, calcification size, and associated medical conditions, were summarized using frequencies and percentages. Descriptive statistical analysis was used to summarize the demographic, clinical, and radiological data of the patients. Categorical variables such as age groups, gender, anatomical location of calcification, morphology, calcification pattern, lesion size, and associated disorders were reported in frequencies and percentages. Cross-tabulations were constructed to compare associated disorders across age groups and gender.

Pearson's chi-square test was applied to assess associations between age group and each associated disorder when test assumptions were sufficiently met. Statistical significance was defined as $p < 0.05$.

Results

The analysis included 169 patients with CT-confirmed intracranial calcifications. Results describe the proportional distribution and the prevalence within this affected study group.

Table 1: Frequency and Percentage Distribution of Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	74	43.8	43.8	43.8
	Female	95	56.2	56.2	100.0
	Total	169	100.0	100.0	

Among the 169 patients, 74 (43.8%) were male and 95 (56.2%) were female. The females were thus more abundant than males and the female/male ratio in the study group was approximately 1.28:1. The percentages reflect the distribution of the patients

with intracranial calcifications by gender, and do not indicate a statistically significant gender difference in the prevalence of intracranial calcifications in the general population.

Table 2: Frequency Distribution of Age Groups

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	10-25	39	23.1	23.1	23.1
	26-40	25	14.8	14.8	37.9
	41-55	41	24.3	24.3	62.2
	56-70	33	19.5	19.5	81.7

	71-85	31	18.3	18.3	100.0
	Total	169	100.0	100.0	

The age distribution of the 169 patients revealed that the highest number of patients were in the age group 41-55 (41 patients; 24.3%). This was followed by the 10-25-year group with 39 patients (23.1%), the 56-

70-year group with 33 patients (19.5%), and the 71-85-year group with 31 patients (18.3%). The lowest proportion was seen in the age group of 26-40 years (25 patients, 14.8%).

Table 3: Frequency Distribution of Reasons for CT examination

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Headache	45	26.6	26.6	26.6
	Seizures	38	22.5	22.5	49.1
	Trauma	23	13.6	13.6	62.7
	Stroke/neurological deficit	34	20.1	20.1	82.8
	Other reasons	29	17.2	17.2	100.0
	Total	169	100.0	100.0	

Headache was the most common reason for CT scans (45 patients, 26.6%). The second most common indication was seizures (38 patients, 22.5%), with stroke or neurological deficit following with 34 patients (20.1%). There were 29 patients

(17.2%) for other clinical indications and 23 patients (13.6%) for trauma. In general, most of the intracranial calcifications were identified during CT examination for neurologic symptoms, headache, or seizures.

Table 4: Frequency Distribution of Associated Disorders

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Hypertension	43	25.4	25.4	25.4
	Diabetes mellitus	32	18.9	18.9	44.4
	Hypoparathyroidism	12	7.1	7.1	51.5
	Chronic kidney disease	20	11.8	11.8	63.3
	Congenital disorder	10	5.9	5.9	69.2
	infectious	25	14.8	14.8	84.0
	Neoplasm	16	9.5	9.5	93.5
	Other disorders	11	6.5	6.5	100.0
	Total	169	100.0	100.0	

The most common disorder found was hypertension (43 patients (25.4%)). Infectious disorders were the second most common condition, with 25 (14.8%) patients reporting, followed by chronic kidney disease with 20 (11.8%) patients. Sixteen patients (9.5%) had neoplasms and 12 (7.1%) had

hypoparathyroidism. Eleven (6.5%) patients had other disorders and ten patients (5.9%) had congenital disorders. The results indicate that vascular and metabolic disorders, especially hypertension and diabetes mellitus, were the most prevalent associated conditions in this study.

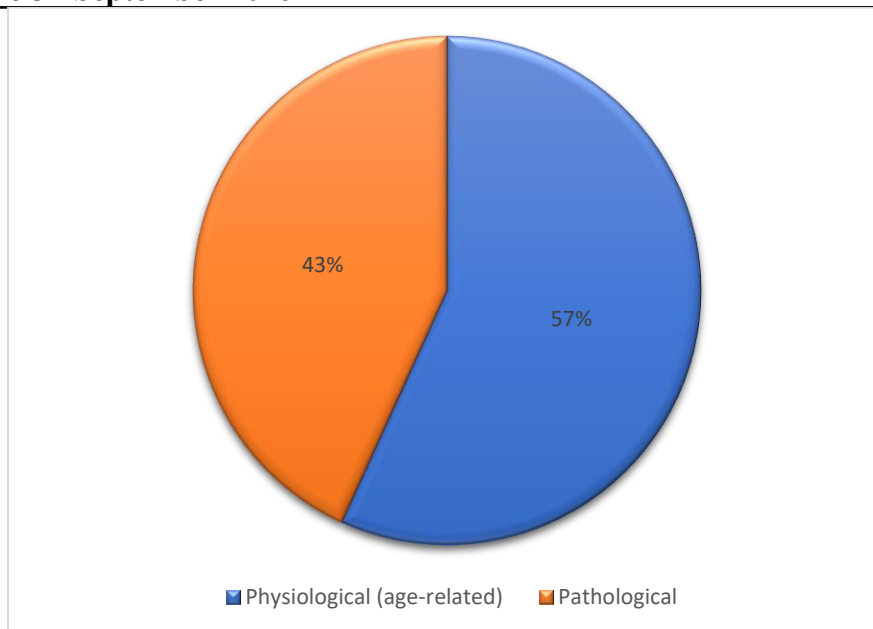


Figure 1: Percentage distribution of types of intracranial calcification

The figure shows the distribution of calcifications of the brain according to physiological or age-related or pathological. Physiological or age-related

calcifications were detected in 96 (56.8%) of the 169 patients; pathological calcifications were detected in 73 (43.2%) of the patients.

Table 5: Frequency Distribution of Shape of Calcification

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Smooth	95	56.2	56.2	56.2
	Irregular	74	43.8	43.8	100.0
	Total	169	100.0	100.0	

The outline of the calcified foci was categorised as smooth or irregular. The 95 (56.2%) had smooth-shaped calcifications and 74 (43.8%) had irregular-shaped calcifications. This indicates that the smooth-

type of calcification was the more commonly reported type of calcification in this study population, but the irregular type was also reasonably well represented.

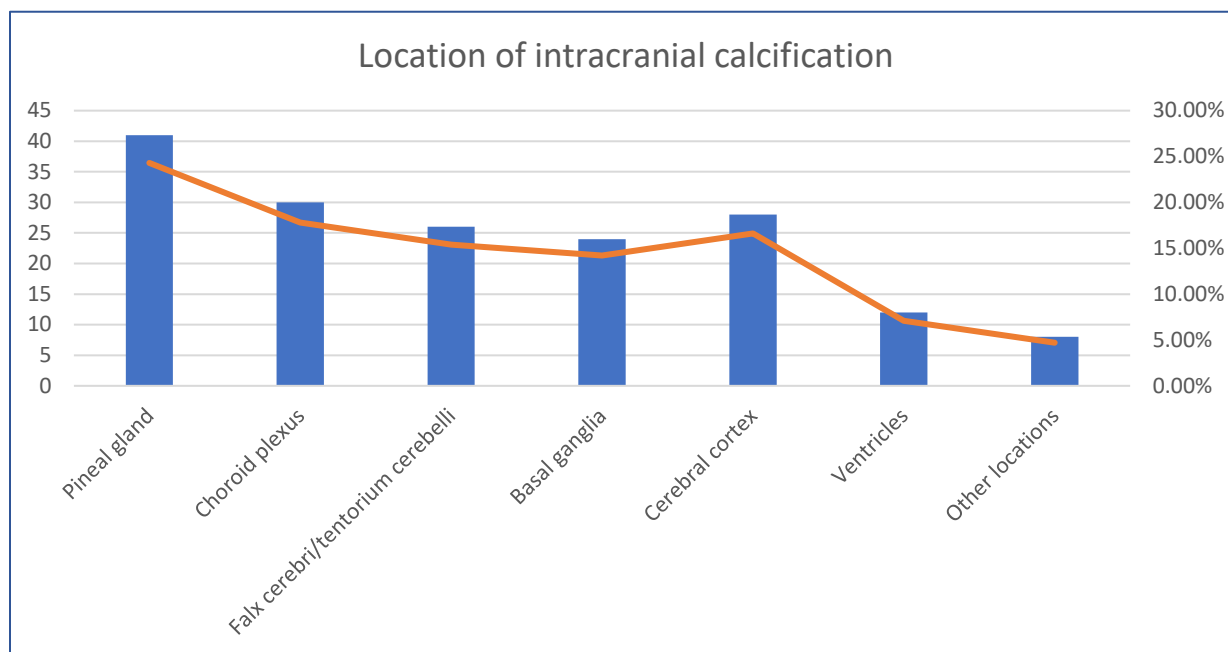


Figure 2 Frequency Distribution of Affected Cerebral Lobes

Intracranial calcification was most commonly seen in the pineal gland (41 patients, 24.3%), followed by the choroid plexus (30, 17.8%) and cerebral cortex (28, 16.6%). 26 patients (15.4%) had calcifications in

the falx cerebri or tentorium cerebelli and 24 patients (14.2%) in the basal ganglia. Ventricular and other locations were relatively rare occurrences (7.1% and 4.7%, respectively).

Table 6: Frequency Distribution of Calcification Pattern

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Punctate	26	15.4	15.4	15.4
	Diffuse punctate	30	17.8	17.8	33.2
	Linear	28	16.6	16.6	49.8
	Curvilinear	20	11.8	11.8	61.6
	Compound	31	18.3	18.3	79.9
	Circular peripheral	34	20.1	20.1	100.0
	Total	169	100.0	100.0	

On the CT it was found that there are six patterns of calcification, which are punctate, diffuse punctate, linear, curvilinear, compound and circular peripheral. Most common was the pattern of circular peripheral calcification (34 patients, 20.1%) and

compound (31, 18.3%) and diffuse punctate (30, 17.8%). The linear type of calcification was present in 28 (16.6%), punctate in 26 (15.4%) and curvilinear type was least common in 20 (11.8%) patients

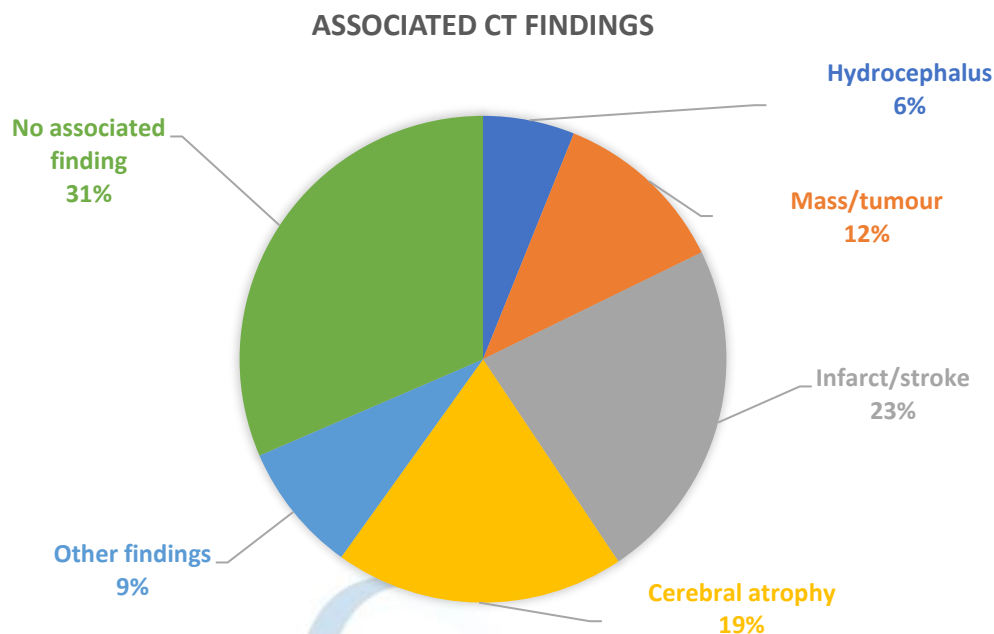


Figure 3 Associated CT Findings Among Patients

The most common associated CT finding in 169 patients was infarct/stroke (45, 26.6%), followed by cerebral atrophy (38, 22.5%), mass/tumour (23,

13.6%), other findings (17, 10.1%) and hydrocephalus (12, 7.1%). 62 patients (36.7%) had no corresponding CT finding.

Table 7: Frequency Distribution of Size of Calcification

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Microcalcifications	87	51.5	51.5	51.5
	Macrocalcification	82	48.5	48.5	100.0
	Total	169	100.0	100.0	

Table 4.6 shows the size distribution of intracranial calcifications. Micro-calcifications were found in 87 patients (51.5%) and macro-calcifications in 82

patients (48.5%). This difference was only 5 patients, showing an almost equal distribution with a slight predominance of micro-calcifications.

Table 8: Cross-tabulation of associated disorders by age group

		10-25yrs	26-40yrs	41-55yrs	56-70yrs	71-85yrs
Valid	Hypertension	4	5	11	11	12
	Diabetes mellitus	4	4	9	7	8
	Hypoparathyroidism	2	2	3	3	2
	Chronic kidney disease	1	3	5	6	5
	Congenital disorder	6	2	1	1	0
	infectious	14	6	3	1	1
	Neoplasm	2	2	5	4	3
	Other disorders	6	1	4	0	0

Infectious and congenital disorders were concentrated in younger patients, whereas hypertension, diabetes mellitus, and chronic kidney disease were more frequent in middle-aged and older groups. Hypertension increased from four cases in

the 10–25-year group to 12 cases in the 71–85-year group. Infectious disorders declined from 14 cases in the 10–25-year group to one case in each of the two oldest groups.

Table 9: Association between age group and associated disorders

		χ^2	df	p-value
Valid	Hypertension	9.133	4	0.058
	Diabetes mellitus	3.362	4	0.499
	Hypoparathyroidism	0.482	4	0.975
	Chronic kidney disease	5.040	4	0.283
	Congenital disorder	9.809	4	0.044
	infectious	24.193	4	<0.001
	Neoplasm	1.548	4	0.818
	Other disorders	10.474	4	0.033

Age group was significantly associated with congenital disorders ($\chi^2=9.809$, $df=4$, $p=0.044$), infectious disorders ($\chi^2=24.193$, $df=4$, $p<0.001$), and other disorders ($\chi^2=10.474$, $df=4$, $p=0.033$). The association with hypertension was borderline but did

not reach statistical significance ($p=0.058$). Diabetes mellitus, hypoparathyroidism, chronic kidney disease, and neoplasm were not significantly associated with age group (all $p>0.05$).

Table 10: Cross-tabulation of associated disorders by gender

		Male	Female	Total
Valid	Hypertension	20	23	43
	Diabetes mellitus	14	18	32
	Hypoparathyroidism	5	7	12
	Chronic kidney disease	9	11	20
	Congenital disorder	5	5	10
	infectious	11	14	25
	Neoplasm	7	9	16
	Other disorders	3	8	11

Hypertension was the most common associated disorder in both sexes, affecting 27.0% of males and 24.2% of females. Diabetes mellitus affected 18.9% of each sex. Infectious disorders were present in 14.9% of males and 14.7% of females, while chronic kidney disease was present in 12.2% and 11.6%, respectively. Overall distributions were comparable; no inferential test of gender differences was reported in the source analysis.

Discussion

This study characterized intracranial calcifications on non-contrast CT in 169 affected patients using

demographic, clinical, and radiological variables. Such a multidimensional approach is clinically relevant because no single imaging feature is sufficient to interpret calcification reliably; age, location, morphology, pattern, size, associated conditions, and accompanying CT abnormalities must be considered together (1,15).

Females represented 56.2% of the cohort and males 43.8%. This is a sample distribution rather than evidence of greater population prevalence among females, because patients without calcification were not included. Published gender distributions vary by calcification type, anatomical

site, underlying disease, and population, so gender should be interpreted alongside clinical and imaging characteristics rather than as an isolated diagnostic parameter (6,30).

The 41–55-year group was the largest (24.3%), while the 10–25-year group was a close second (23.1%); overall, 62.1% of participants were older than 40 years. The representation of middle-aged and older adults is consistent with increasing physiological and vascular mineral deposition with age (2,20,29). The substantial younger group is clinically important because calcification at younger ages may indicate infectious, congenital, metabolic, or endocrine disorders requiring evaluation (12,34,35).

Headache was the most common indication for CT (26.6%), followed by seizures (22.5%) and stroke or neurological deficit (20.1%). These findings indicate that most calcifications were identified during assessment of neurological symptoms; however, the cross-sectional design cannot establish that calcification caused the presenting complaint. This distinction is particularly important in patients with seizures, because calcified neurocysticercosis and other parenchymal calcified lesions may be epileptogenic (32,33).

Physiological/age-related calcifications predominated (56.8%), consistent with the frequent incidental occurrence of calcification at typical sites during aging. Nevertheless, pathological calcifications accounted for 43.2% of cases. This substantial proportion argues against automatically dismissing intracranial calcification as benign, particularly when patient age, location, symmetry, morphology, or accompanying CT abnormalities are atypical (14,24–26).

The pineal gland (24.3%) and choroid plexus (17.8%) were the leading locations, consistent with recognized sites of physiological calcification (3,4,29). Calcification involving the cerebral cortex (16.6%) or basal ganglia (14.2%) has a broader differential diagnosis that includes infectious, vascular, metabolic, endocrine, congenital, and genetic disorders, especially when distribution is extensive or atypical (7,31).

Smooth morphology was observed in 56.2%, while 43.8% were irregular. Circular peripheral (20.1%), compound (18.3%), and diffuse punctate (17.8%) were the most frequent patterns. Microcalcifications (51.5%) and macrocalcifications (48.5%) were nearly equally distributed. This heterogeneity supports the complementary use of morphology, pattern, size, anatomical distribution, and clinical context rather than reliance on a single characteristic (7,19).

Hypertension (25.4%), diabetes mellitus (18.9%), infectious disorders (14.8%), and chronic kidney disease (11.8%) were the leading associated conditions. Vascular and metabolic comorbidities may coexist with intracranial vascular calcification, and prior studies have linked intracranial arterial calcification with vascular risk markers and adverse cerebrovascular outcomes (11,38,39).

Age-related patterns were evident in cross-tabulations. Infectious and congenital disorders were concentrated in younger patients, whereas hypertension, diabetes mellitus, and chronic kidney disease were more frequent in middle-aged and older groups. Significant associations were found between age group and congenital disorders, infectious disorders, and other disorders. The particularly strong association with infectious disorders emphasizes consideration of neuroinfection in younger patients, especially in settings where neurocysticercosis remains relevant (32,33). Hypertension showed a borderline but non-significant association with age, and diabetes mellitus, hypoparathyroidism, chronic kidney disease, and neoplasm showed no significant age association.

The distribution of associated disorders was broadly comparable between males and females. No additional CT abnormality was recorded in 36.7% of patients. Among those documented, infarct/stroke (26.6%) and cerebral atrophy (22.5%) were most common, likely reflecting the vascular and degenerative burden of a hospital-based neurological cohort; direct causal attribution cannot be made from these data.

Overall, non-contrast CT was useful for detecting and morphologically characterizing intracranial

calcifications. Structured reporting of type, location, morphology, pattern, size, and associated findings may help distinguish typical physiological calcification from lesions requiring further evaluation (15,22,25).

Conclusion

Among 169 patients with CT-confirmed intracranial calcifications, females and patients aged 41–55 years constituted the largest demographic groups. Physiological/age-related calcifications predominated, but pathological calcifications accounted for more than two-fifths of cases. Pineal location, smooth morphology, circular peripheral pattern, and microcalcification were the most frequent imaging characteristics. Hypertension, diabetes mellitus, and infectious disorders were the leading associated conditions. Age group was significantly associated with congenital, infectious, and other disorders, with infectious and congenital conditions concentrated among younger patients and vascular/metabolic conditions more frequent among older patients. Infarct/stroke was the most common additional CT finding.

Non-contrast CT provides effective detection and characterization of intracranial calcifications, but interpretation should integrate age, clinical presentation, location, morphology, pattern, size, and associated findings. Because only patients with intracranial calcifications were included, the results represent within-cohort frequency distributions rather than true prevalence among all patients undergoing CT brain imaging.

Limitations

- The cross-sectional design limited assessment of temporal or causal relationships.
- The hospital-based convenience sample may limit generalizability to the wider population.
- Because only patients with intracranial calcifications were included, overall, age-specific, and gender-specific prevalence among all patients undergoing CT brain imaging could not be calculated.
- Physiological and pathological calcifications were not analyzed as separate outcome groups, and

the study did not include longitudinal follow-up or advanced quantitative assessment of calcification burden.

Recommendations

- Future multicenter studies should include all patients undergoing CT brain examinations to determine true overall, age-specific, and gender-specific prevalence.
- Standardized radiology reports should document calcification type, location, morphology, pattern, size, symmetry, and associated CT findings.
- Atypical calcifications, particularly in younger or symptomatic patients, should be correlated with clinical findings, laboratory investigations, and complementary imaging.
- Larger prospective and longitudinal studies should identify independent predictors and evaluate associations with seizures, stroke, cognitive decline, and other neurological outcomes.

Declarations

Ethics approval: Ethical approval was obtained from the Ethical Review Committee of Superior University, Lahore, with administrative permission from the participating hospitals. The approval/reference number should be inserted before journal submission.

Consent to participate: Consent procedures and access to retrospective records were handled in accordance with the conditions approved by the relevant ethics committee and participating institutions.

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Competing interests: The authors declare no competing interests.

Data availability: The data generated and analyzed during this study are available from the corresponding author upon reasonable request.

Author contributions: Zarwa Gohar conducted data collection, data analysis, interpretation, and manuscript drafting. Muhammad Adnan Hafeez supervised the study, contributed to methodology

and interpretation, and critically reviewed the manuscript. Both authors approved the final manuscript.

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