

BMJ Open Prevalence and characteristics of thoracic ossification of the posterior longitudinal ligament in 3299 Black patients: a cross-sectional study of a prospectively registered database

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ABSTRACT

Objectives To the best of our knowledge, the prevalence of thoracic ossification of the posterior longitudinal ligament (T-OPLL) in the Black population has never been studied and is still unknown. The purpose of this study was to examine the prevalence and characteristics of T-OPLL in the Black patients.

Methods This is a cross-sectional study. All patients who underwent chest CT for the trauma screening and whose race was classified as 'Black' on the questionnaire were recruited in the study from March 2019 to March 2020. Demographic data, including age, sex, body mass index (BMI) and presence of diabetes mellitus (DM), were recorded. T-OPLL was defined as ectopic OPLL of more than 2 mm thickness in the axial plane image of the CT scan. The prevalence and characteristics of T-OPLL, and the association of T-OPLL with BMI and DM were evaluated.

Results A total of 3299 Black patients (1507 women and 1792 men) were included for the analysis. The prevalence of T-OPLL was 1.5% (50 patients), with 2.4% for females and 0.8% for males. The highest prevalence was observed in patients at the age of 70 years (3.8%). Thickness of T-OPLL was between 2 and 3 mm in 46% (23/50) of the patients, and the largest thickness was 6.1 mm. T-OPLL was significantly associated with female sex and the presence of DM.

Conclusions The prevalence of T-OPLL was 1.5% in the 3299 Black patients who underwent chest CT for the trauma screening, with 2.4% for females and 0.8% for males.

INTRODUCTION

Ossification of the posterior longitudinal ligament (OPLL) is a condition of ectopic bone formation within the posterior longitudinal ligament.¹ Although genetic association has been reported, the pathophysiology of OPLL is not fully understood.^{2,3} OPLL can cause serious neurological compromise through the compression of spinal cord.^{4,5}

The prevalence of OPLL has been reported to be 0.6–6.3%.^{1,6–17} The recent analysis by

STRENGTHS AND LIMITATION OF THIS STUDY

- ⇒ This is the first study to examine the prevalence of thoracic ossification of the posterior longitudinal ligament (T-OPLL) in the Black population.
- ⇒ The analysis was performed using CT.
- ⇒ The participants in this study may not represent the general population and may have a selection bias due to the limited area (New York City). However, because it is unethical to obtain CT scans of normal volunteers, we think that our study participants may represent the best possible sampling for the general population.
- ⇒ The association between T-OPLL and clinical presentation could not be assessed.

multislice CT has revealed a higher prevalence of OPLL than previously reported using conventional plain radiographs.^{11–13,16} Actually, conventional plain radiograph is not an adequate modality for the diagnosis of thoracic OPLL (T-OPLL) because the radiographical evidence of T-OPLL can be masked by the shoulder and ribs.^{1,18} Thus, the prevalence study of T-OPLL should be performed using multislice CT.

The difference in the prevalence of OPLL among the races has been reported.¹² OPLL has been assumed to occur predominantly in the East Asian population, particularly in Japanese,¹⁹ and many of the studies are from the Asian countries.^{1,7–16} However, such studies in races other than the Asians are limited, and those in the Black population are extremely limited. To the best of our knowledge, the prevalence of T-OPLL in the Black population has never been studied and is still unknown.

The purpose of this study was to examine the prevalence of T-OPLL in the Black patients within the USA who underwent multislice chest CT for the trauma screening.

We also analysed the characteristics of T-OPLL in the Black patients, and the association of T-OPLL with body mass index (BMI) and diabetes mellitus (DM).

MATERIAL AND METHODS

Patient and public involvement statement

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

Study participants

This study was approved by our institutional review board (Kings County Hospital Centre, STUDY00002324). A cross-sectional review of a prospectively registered database in New York City Health and Hospitals (11 hospitals in New York City) was performed. All patients who underwent chest CT for the trauma screening at the Emergency Department and whose race was classified as 'Black' on the questionnaire were recruited in the study from March 2019 to March 2020. We used 'Black' because this was the term used on the questionnaire and 'Black' can include 'African-American' and 'Caribbean-American'. The patients with previous thoracic spine surgery were excluded from the study. Demographic data, including age, sex, BMI and the presence of DM were recorded. These data were based on a questionnaire completed at the initial visit to the trauma centre.

Radiographic assessment

T-OPLL was defined as ectopic OPLL of more than 2 mm thickness in the axial plane image of the CT scan.²⁰ This size was based on the previous criteria which stated that more than a 2 mm increment was regarded as growth.^{21–23} Osteophytes located near the uncovertebral joint or at the corners of the vertebrae were assumed to be degenerative in nature and were considered calcified disc (not considered OPLL). The level involved by T-OPLL was evaluated using sagittal reconstruction images. The thickness of T-OPLL was evaluated using axial plane images. Types of T-OPLL were classified into five types according to the previous report using sagittal reconstruction images: linear, beaked, continuous waveform, continuous cylindrical or mixed type (composed of at least two of the first four types) (figure 1).²⁴

All CT scans were acquired using a multidetector CT with the following parameters: slice thickness, 1.25 mm; pixel size, 0.352 mm; tube rotation speed, 0.5 s; beam collimation, 40 mm; beam pitch, 0.9; tube current, 200 mA and voltage, 120 kV. Both axial images and reconstructed sagittal images were examined with a Picture Archiving and Communication System (PACS) viewer.

Images were reviewed by two orthopaedic surgery residents (VN and EH), who were trained by an experienced orthopaedic spine surgeon (HY) to identify and classify OPLL via CT scan. After screening all images, T-OPLL cases were reviewed again and confirmed by

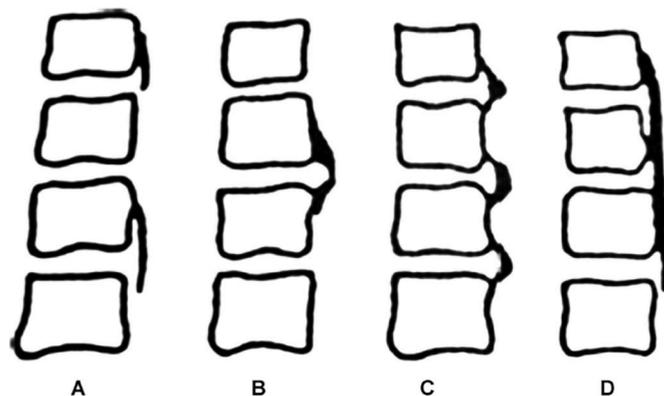


Figure 1 Classification of thoracic ossification of the longitudinal ligament (T-OPLL). A, linear type. B, beaked type. C, continuous waveform type. D, continuous cylindrical type. Mixed type is defined as a combination of two or more different types.

HY. Differences were settled by consensus to minimise intraobserver and interobserver bias and errors.

Statistical analysis

Student's t-test and χ^2 test were used when appropriate. A p-value of less than 0.05 was considered statistically significant. Statistical analysis was performed using JMP Pro, V.15 software (JMP, V.15, SAS Institute, Cary, NC).

RESULTS

Demographic data

A total of 3299 Black patients were included in the analysis (table 1). Of the 3299 patients, 1507 were females and 1792 were males, with the mean age of 57.6±17.1 years (range, 5–103). BMI data were available for 92.2% of the patients. Mean BMI was 27.8±7.0 kg/m. Based on the questionnaire, 1121 patients (34.0%) had a diagnosis of DM.

Prevalence and characteristics of T-OPLL

Of the 3299 patients, there were 50 patients with T-OPLL (36 females and 14 males) (tables 1 and 2). The overall prevalence of T-OPLL was 1.5%, with 2.4% for females and 0.8% for males. The prevalence of T-OPLL in female patients was significantly higher than that in male patients (2.4% vs 0.8%, $p=0.003$). The mean age of patients with T-OPLL was significantly higher than that without T-OPLL (64.6 vs 57.5, $p=0.0013$).

With regard to the prevalence of T-OPLL among each 10-year age group, the highest prevalence was observed in patients at the age of 70 years (3.8%), followed by the age of 80 years (1.8%) and the age of 40 years (1.5%) (figure 2). The distribution of T-OPLL in the thoracic spinal segments is shown in figure 3. T-OPLL was most frequent at T8, followed by T12. The thickness of T-OPLL is shown in table 3. The thickness was between 2 and 3 mm for 23 patients, between 3 and 4 mm for 20 patients and larger than 4 mm for 7 patients. Largest thickness of T-OPLL was 6.1 mm. The distribution of different type

Table 1 Distribution of the study population according to T-OPLL (+) or (-)

	T-OPLL (+)	T-OPLL (-)	All
Sex	N	N	N
Male	14	1778	1792
Female	36	1471	1507
Age, mean	64.6	57.5	57.6
Age group, years	N (%) [*]	N	
<10	0	7	7
10–19	0	31	31
20–29	1 (0.5)	219	220
30–39	1 (0.3)	318	319
40–49	5 (1.5)	332	337
50–59	10 (1.4)	705	715
60–69	8 (1.0)	832	840
70–79	21 (3.8)	528	549
80–89	4 (1.8)	224	228
90–99	0	51	51
>100	0	2	2
Total (%)	50 (1.5)	3249	3299

^{*} T-OPLL (+) percentage per age group.
T-OPLL, thoracic ossification of the posterior longitudinal ligament.

of ossification is summarised in [table 4](#). Most frequently encountered type was beaked type (28 patients), followed by linear type (12 patients) and continuous waveform (8 patients). Continuous cylindrical type was found in two patients.

Association between T-OPLL and BMI/DM

There was no difference in the mean BMI between patients with and without T-OPLL (26.7 vs 27.8, $p=0.44$) ([table 2](#)). No difference was found in the mean BMI between female patients with and without T-OPLL (26.7 vs 27.5, $p=0.82$), and between male patients with and without T-OPLL (26.7 vs 28.0, $p=0.39$). The presence of DM was significantly higher in patients with T-OPLL than those without T-OPLL (90.0% vs 33.1%, $p<0.0001$) ([table 2](#)). The presence of DM was significantly higher in female and male patients with T-OPLL than those without T-OPLL (female: 91.7% vs 27.9%, $p<0.0001$; male: 85.7% vs 37.4%, $p=0.002$; respectively).

DISCUSSION

Our study revealed that the prevalence of T-OPLL in the Black patients was 1.5%. Previous studies analysed plain chest radiographs in Japanese and reported the prevalence of T-OPLL was 0.56% and 0.8%.^{14 15} Mori *et al*¹ found 1.9% prevalence of T-OPLL in chest CT of 3013 pulmonary disease patients. Furthermore, two recent positron emission tomography and CT (PET-CT) studies revealed 1.6% in Japanese and 2.25% in Chinese.^{13 16} Thus, all of the previous studies reported the prevalence of T-OPLL in the Asians, and our study first reported the prevalence of T-OPLL in the Black population. OPLL has been assumed to occur predominantly in the Asian population.¹⁹ Our study showed the prevalence of T-OPLL in the Black population seems to be equivalent to that in the Asian population based on the CT analysis. Our study also revealed the prevalence of T-OPLL in females was significantly higher than that in males ($p=0.003$). This result is consistent with the previous reports. Four studies among the above five studies reported a higher prevalence of

Table 2 Characteristics of T-OPLL (+) and T-OPLL (-) individuals in the study population

	T-OPLL (±)					
	Male		Female		Total	
	+	-	+	-	+	-
Number	14	1778	36	1471	50	3249
%	0.8		2.4		1.5	
Age (mean±SD), year	60.4±13.4	55.2±17.3	66.2±12.1	60.2±16.6	64.6±12.6	57.5±17.1
<i>P</i>	0.23		0.014		0.0013	
BMI (mean±SD), kg/m ²	26.7±7.6	28.0±7.0	26.7±5.9	27.5±7.0	26.7±6.3	27.8±7.0
<i>P</i>	0.39		0.82		0.44	
Diabetes						
Present	12	665	33	411	45	1076
Not present	2	1113	3	1060	5	2173
<i>P</i>	0.002		<0.0001		<0.0001	

Age and BMI were presented as mean±SD.

The bolded and italic values represent labels for the data.

^{*}BMI was based on a total N of 3044; T-OPLL (+) = 45; male=13, female=32; T-OPLL (-) = 2999; male=1622, female=1377.

BMI, body mass index; T-OPLL, thoracic ossification of the posterior longitudinal ligament.

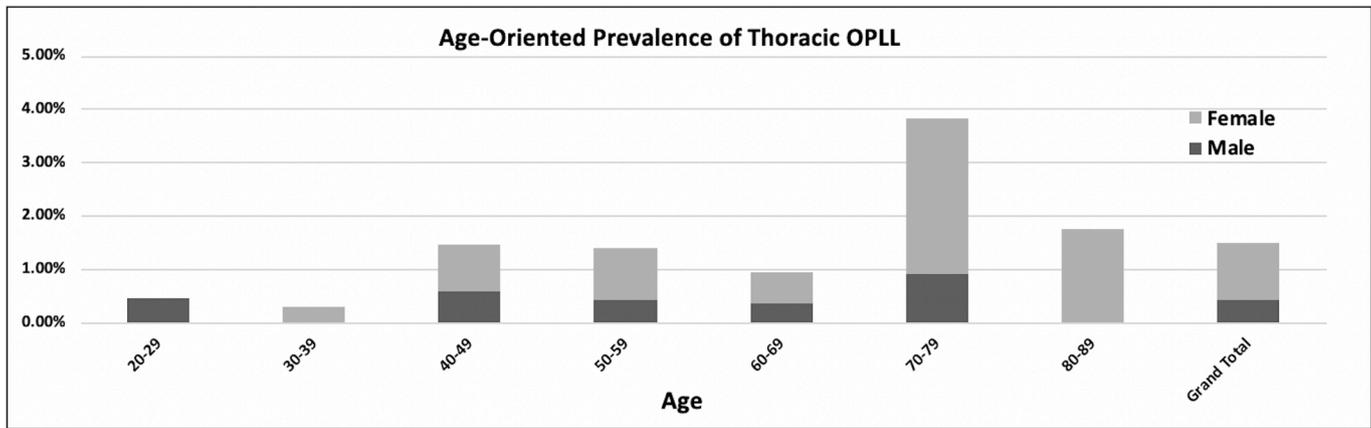


Figure 2 The prevalence of thoracic ossification of the posterior longitudinal ligament (T-OPLL) among each 10-year age group. The vertical axis indicates the percentage. The prevalence of T-OPLL at age ≤ 19 -years and age ≥ 90 -years was zero.

T-OPLL in females.^{1 13 14 16} Thus, female sex could be a risk factor for T-OPLL.

The definition of the disease should be consistent for the prevalence study; otherwise, the results could be confusing. Mori *et al*¹ defined T-OPLL when the thickness in axial plane images of CT scan is more than 3mm; in contrast, Fujimori *et al*¹³ and Liang *et al*¹⁶ defined T-OPLL as more than 2mm. In our study, we defined T-OPLL as more than 2mm. If we defined it as more than 3mm, similar to Mori *et al*,¹ the prevalence of T-OPLL became

0.8% from 1.5%. This difference emphasises the importance of the definition.

Our study demonstrated that the prevalence of T-OPLL was the highest at the age of 70 years (3.8%), followed by the age of 80 years (1.8%). Mori *et al*¹ found that the peak prevalence of T-OPLL was noted at the age of 60 years in Japanese. Fujimori *et al*¹² reported that the highest prevalence of cervical OPLL was observed in patients between 75 and 85 years of age (5.0%), followed by those between 65 and 75 years of age (4.7%), in patients in San

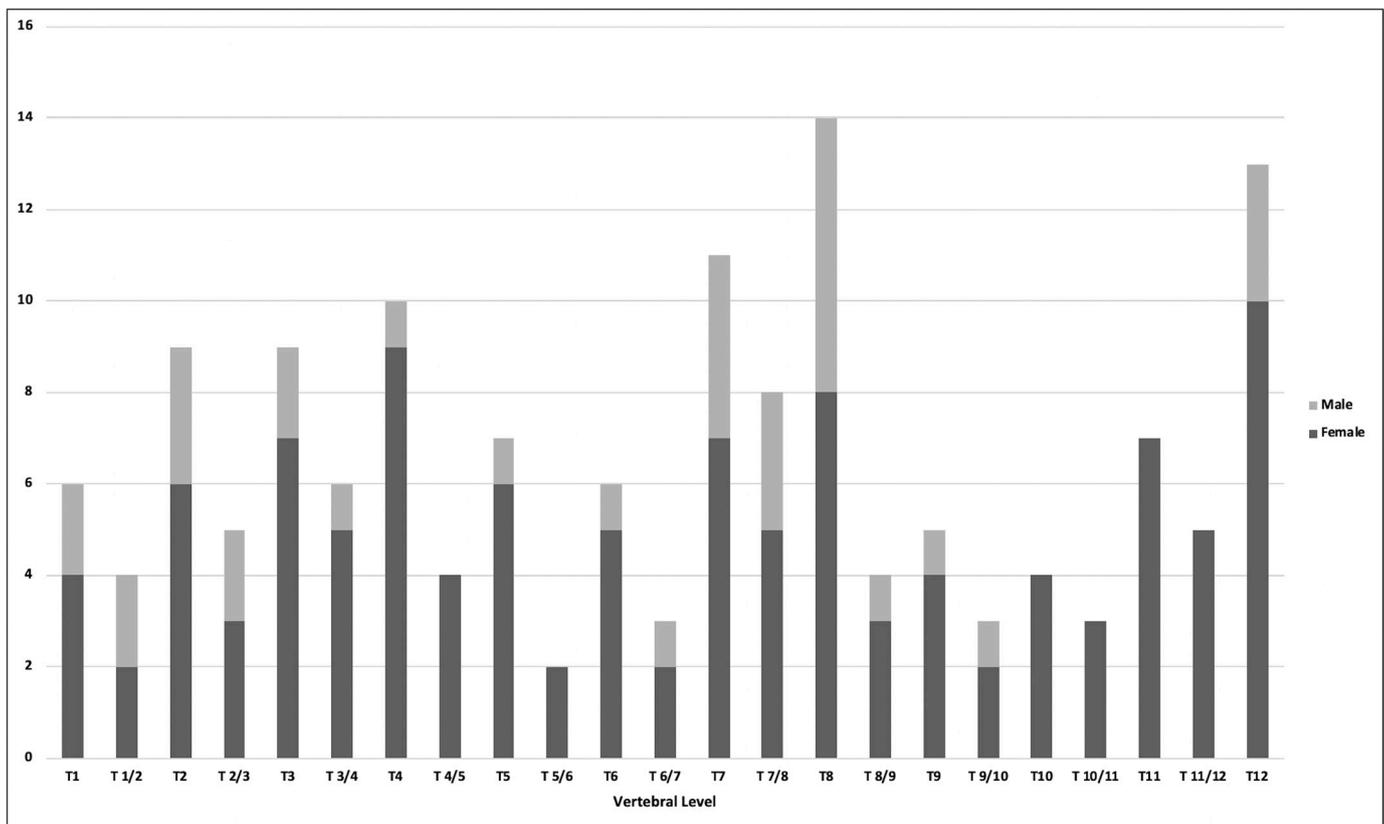


Figure 3 The distribution of thoracic ossification of the posterior longitudinal ligament (T-OPLL) based on the vertebral level. The vertical axis indicates the number of patients.

Table 3 Thickness of T-OPLL

Thickness of T-OPLL (mm)	No. of patients
2–3	23
3–4	20
>4	7

T-OPLL, thoracic ossification of the posterior longitudinal ligament.

Francisco Bay area. Thus, our results may also support the age-related aspect of OPLL.

In our study, T-OPLL was most frequent at T8, followed by T12. This result is inconsistent with the previous reports.^{1 13 16 20} Tsuyama *et al*²⁰ reported that T-OPLL occurred the most at T5/T6 in Japanese on plain chest radiographs, although T-OPLL could be masked by the shoulder and ribs on plain chest radiographs. Mori *et al*¹ revealed that the most frequently involved site by T-OPLL was at T3/T4 in Japanese, by using chest CT. Fujimori *et al*¹³ found T-OPLL occurred the most at T1/T2 in Japanese, by using PET-CT. In Liang *et al*'s¹⁶ study using PET-CT, T-OPLL was also most frequent at T1/T2 in Chinese. With regard to the T-OPLL type, the most frequently encountered type in our study was beaked type, followed by linear type. In Mori *et al*'s study,¹ it was linear type, followed by cylindrical type in Japanese. These are the interesting findings of T-OPLL in the Black population; however, there is no clear explanation for this difference at this point.

None of the previous studies reported the thickness of T-OPLL. Our study revealed that, in the Black patients, the thickness of OPLL was between 2 and 3 mm in 46% of T-OPLL cases and the largest thickness was 6.1 mm. Matsunaga *et al*²⁵ showed more than 60% spinal canal stenosis by cervical OPLL was radiographic risk factors for development of myelopathy in patients with cervical OPLL. In Mori's study,¹ none of T-OPLL extended more than 50% of the anteroposterior diameter of the spinal canal. In our study, none of T-OPLL occupied more than 40% of the spina canal and most of T-OPLL occupied less than 25%. Future studies are necessary to find out the association of thickness of T-OPLL or space available for spinal cord with clinical presentation.

Table 4 Distribution of ossification type in patients with T-OPLL

Type of ossification	No. of patients		
	Male	Female	Total
Beaked	8	20	28
Linear	4	8	12
Continuous waveform	2	6	8
Continuous cylindrical	0	2	2

T-OPLL, thoracic ossification of the posterior longitudinal ligament.

Many of the previous studies reported that high BMI and DM are the risk factors for OPLL.^{1 17 26 27} Our study also demonstrated that the presence of DM was significantly higher in patients with T-OPLL than those without T-OPLL ($p < 0.0001$). The exact mechanism is unclear, but it is thought that insulin might stimulate osteoprogenitor cells, which results in OPLL.^{8 27} Mori *et al*¹ found that there was a significant difference of BMI between T-OPLL positive and T-OPLL negative individuals ($p = 0.0076$); however, our study revealed no difference in the mean BMI between patients with and without T-OPLL ($p = 0.44$).

Our study had several limitations. First, the participants in this study may not represent the general population and may have a selection bias due to the limited area (New York City). However, because it is unethical to obtain CT scans of normal volunteers, we think that our study participants may represent the best possible sampling for the general population. Second, there was no information regarding the clinical presentation caused by T-OPLL. Thus, the association between T-OPLL and clinical presentation could not be assessed. Third, we were unable to differentiate type 1 and type 2 DM. Fourth, Kappa analysis to determine interobserver and intraobserver reliabilities was not performed because the expected prevalence was quite low; however, controversial cases were discussed and determined by all authors. Fifth, no a priori sample size calculation was carried out; however, in Fujimori's study, they wrote the calculation process of OPLL and found a sample size of at least 1521 participants was estimated to be necessary to examine the prevalence of OPLL.¹² Thus, 3299 patients should be more than enough. Despite these limitations, we believe that our data are invaluable because this is the first study to examine the prevalence of T-OPLL in the Black population.

CONCLUSION

The prevalence of T-OPLL was 1.5% in the 3299 Black patients who underwent chest CT for the trauma screening, with 2.4% for females and 0.8% for males. The highest prevalence was observed in patients at the age of 70 years (3.8%). Thickness of T-OPLL was between 2 and 3 mm in 46% (23/50) of the patients, and the largest thickness was 6.1 mm. T-OPLL was significantly associated with female sex and the presence of DM.

Contributors HY initiated the collaborative project, designed data collection tools, implemented the study, monitored data collection for the whole study, analyzed the data, and drafted and revised the paper. He is guarantor. VN and EH helped develop data collection tools, monitored data collection for the whole study, wrote the statistical analysis plan, cleaned and analyzed the data, and helped revise the paper.

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Disclaimer The funder did not have a role in the study.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting or dissemination plans of this research.

Patient consent for publication Not required.



Ethics approval This study involves human participants and was approved by Ethics name ID Kings County Hospital Centre, STUDY00002324. Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article or uploaded as supplementary information.

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