CHAPTER VII
DISCUSSION
DISCUSSION

Tuberculosis is known to mankind since times immemorial. Globally, nearly 30 million people suffer the disease and WHO estimates that it kills 1.7 million people a year worldwide. India alone accounts for one fifth of the total cases. Decrease in the incidence of TB was noted due to better healthcare.27,28

Vertebral TB is the most common form of skeleton TB and constitutes 50% of all the cases. Spinal TB is a paucibacillary disease. A histopathological/ bacteriological/ cytological diagnosis which forms the gold standard for diagnosis of TB is not always possible because it is a deep seated lesion.1-5

Spinal TB can be diagnosed clinically by the clinical picture of malaise, loss of weight, loss of appetite, evening rise of temperature, back stiffness & backache, raised ESR, paravertebral muscle spasm and deformities of the spine; and radiologically by pain X-Rays, CT and MRI.1-5

The present study was done in 50 patients with diagnosis of TB of spine who presented to medical college and hospital, Pt. B.D. Sharma, PGIMS Rohtak to know the patho-physiologic behavior of the TB and its response to treatment. Detailed clinical & physical examination and routine laboratory investigations were done.

A) Demographic profile

1. Age and Sex:

The age group of patients ranged from 17-70 years with mean age of 42.76±15.74 years. There was male preponderance in the study. The study population comprised of 60% male and 40% female. Similar observations were made by Kim et al and Al-Mulhim et al (Table 19).
Table 19

<table>
<thead>
<tr>
<th>Authors</th>
<th>Mean age (years)</th>
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</thead>
<tbody>
<tr>
<td>Kim et al (1994)</td>
<td>39.3</td>
</tr>
<tr>
<td>Al-Mulhim et al (1995)</td>
<td>43.6</td>
</tr>
<tr>
<td>Alothman (2001)</td>
<td>52.8</td>
</tr>
<tr>
<td>Cormican et al (2006)</td>
<td>35.1</td>
</tr>
<tr>
<td>Jain and Dhammi (2007)</td>
<td>15.6</td>
</tr>
<tr>
<td>Bakhsh (2010)</td>
<td>31.7</td>
</tr>
<tr>
<td>Present study (2012)</td>
<td>42.7</td>
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Twenty two out of 50 patients in the present study were between 21 to 40 years of age. This reflects that TB affects young and productive age group.

2. Duration of symptoms

The large spread in symptom duration before diagnosis reflects the variable and chronic nature of this disease and may also be a function of a delay in self presentation. In our study patients were suffering from the symptomatology with a mean duration of 8.3±8.89 months; (range: 1-36 months) (Table 20). Majority of the patients were seen and treated by the health practitioners with non-steroidal anti-inflammatory drugs with a presumptive diagnosis of other mechanical problems of the back.

Table 20

<table>
<thead>
<tr>
<th>Authors</th>
<th>Duration of symptoms</th>
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</thead>
<tbody>
<tr>
<td>Liu et al (1993)</td>
<td>2 months- 24 months</td>
</tr>
<tr>
<td>Kim et al (1994)</td>
<td>1 months- 48 months</td>
</tr>
<tr>
<td>Page et al (2006)</td>
<td>1 month- 28 months (7 months)</td>
</tr>
<tr>
<td>Cormican et al (2006)</td>
<td>1.5 months- 36 months (11 months)</td>
</tr>
<tr>
<td>Present study (2012)</td>
<td>1 month- 36 months (8.3 months)</td>
</tr>
</tbody>
</table>
3. Symptomatology

Backache was the most common symptom in our study. Severe backache was present in all subjects, constitutional symptoms were present in 48% patients and deformity was present in 50% patients during the initial visit. All this symptomatology subsequently decreased, following treatment in form of ATT and by the end of 24 months mild and occasional pain persisted in (12%) and (22%) patients respectively. Nonsteroidal anti-inflammatory drugs (NSAIDS) are effective in alleviation of back pain and might be useful in the early course of the disease to prevent bony destruction attributable to non specific synovial membrane inflammation, and to inhibit or to minimize the bone resorption by prostaglandins. Therefore, NSAIDS are recommended to be used in combination with ATT at early stage of treatment for 4-6 weeks.80

Ninety-eight percent patients were free of constitutional symptoms by the end of 9th month of the treatment. Page et al reported that weight gain was nearly maximal at 6 month, and pain relief was achieved within nine months.61

Deformity kept on increasing as the disease progressed & 32 subjects developed deformity by 12th month and persisted till the end of study period. Neurological deficit improved in 9 (18%) patients, but persisted in 2 (4%) patients. The clinical features of TB spine in the present series were fairly similar to that described in the previous studies.51,61,81 The frequency of neurological involvement has been found vary across studies from 23% to 76% of patients (Table 21).35,82-84

Table 21

<table>
<thead>
<tr>
<th>Authors</th>
<th>Backache</th>
<th>Constitutional symptoms</th>
<th>Deformity</th>
<th>Neurological deficit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kim et al (1994)</td>
<td>96%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Desai et al (1994)</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alothman (2001)</td>
<td>84%</td>
<td>32%</td>
<td>17%</td>
<td>28%</td>
</tr>
<tr>
<td>Page et al (2006)</td>
<td>95%</td>
<td>84%</td>
<td></td>
<td>74%</td>
</tr>
<tr>
<td>Cormican et al (2006)</td>
<td>100%</td>
<td>38%</td>
<td></td>
<td>29%</td>
</tr>
<tr>
<td>Baksh (2010)</td>
<td>100%</td>
<td>46%</td>
<td>34.6%</td>
<td>38.4%</td>
</tr>
<tr>
<td>Present study (2012)</td>
<td>100%</td>
<td>48%</td>
<td>50%</td>
<td>22%</td>
</tr>
</tbody>
</table>

39
B) Laboratory investigations

1. Anaemia:

Anaemia was observed in 16 patients during the initial visit. Possible cause for anaemia could be due to loss of appetite which further improved and persisted in just 2 patients by 12\textsuperscript{th} and 24\textsuperscript{th} month. Cormican et al\textsuperscript{51} reported that 87.5\% of their patients had evidence of anaemia; while Baksh\textsuperscript{79} reported low hemoglobin in all cases.

2. Erythrocyte sedimentation rate (ESR):

An increased ESR is not thought to be significant in diagnosis of TB, but is considered to be a useful measure for assessing the response to chemotherapy.\textsuperscript{3,83} Moon et al reported average ESR of 36 mm/hour, which became normal within 3-6 months.\textsuperscript{2} Page et al reported elevated ESR present in 84\% patients returning to normal (<30 mm/hr) after 3 months of treatment. Their data suggested that laboratory inflammatory syndrome should disappear after three months of treatment and patient should recover their previous clinical status after 6 months of treatment.\textsuperscript{61} Alothman et al reported that ESR was high (20-40 mm/hr) in 21.4\% and very high (>40 mm/hr) in 73.2\% of the cases.\textsuperscript{77} Baksh reported that ESR was significantly raised in all cases. In more than 50\% cases, it was above 60 mm/hr.\textsuperscript{79} In the present study, ESR was found to be raised in all the patients in initial visit with mean value of 53.54. Sustained increase in mean ESR value (>20mm/hr) was observed till 12\textsuperscript{th} month follow up. ESR levels reached normal in majority of patients by 18\textsuperscript{th} month.

3. Other laboratory parameters:

Leucocytosis was observed in few patients during initial and 6\textsuperscript{th} month visit, which subsequently improved after the initiation of the treatment. Serum bilirubin and SGOT/SGPT was found to be increased in very few patients. This increase was found in 6\textsuperscript{th} and 12\textsuperscript{th} months and could be due to antitubercular treatment. Mantoux test was positive in all 100\% subjects. Alothman et al reported abnormal liver functions in 32\% of the patients, and increased white cell count only in 16\%. Other parameters, such as absolute lymphocytes and monocytes counts or monocytes/lymphocyte ratio in blood, were not found to be helpful for diagnosis.\textsuperscript{77} Baksh reported mild leucocytosis in all
cases. All other laboratory investigations were found to be within normal limits. Tuberculin test was positive in 57% cases.

C) Duration of antitubercular treatment:

In the present study, treatment lasted 13.1 months (range 12-18 months). Medical Research Council advocates short-course chemotherapy (6 months) for uncomplicated spinal TB. In the study by Cormican et al mean duration of treatment was 13 months (range: 9-24 months). The total duration of treatment and number of drugs required are still controversial. The British Thoracic Society recommends six months, the American Thoracic Society recommends nine months of treatment for adults, and American Academy of Pediatrics recommends twelve months of treatment with bone TB. A critical analysis of the literature shows that proof is still lacking of the equivalence between six and nine months, and twelve months of the treatment.

D) Radiological investigations:

1. Chest X-Ray:

X-Ray chest revealed pulmonary TB in 32% patients in the present study. Desai et al found associated pulmonary TB on chest skiagram in 26% patients. Alothman et al found that chest radiograph was normal in 56 cases (86% of the 65 cases where it was done). Associated pulmonary disease (active or healed) can be seen in approximately in 30%-50% cases.

2. Radiography of spine

i. Region

Spinal TB most commonly involves the thoracic spine and the lumbar spine, involvement of the cervical region and sacrum is less common. In our study also these two regions were predominantly involved.

ii. Type of involvement

The infection usually begins in the anterior aspect of the vertebral body, either inferiorly or superiorly, adjacent to the vertebral end plate. Focal areas of erosion and osseous destruction in the anterior corners of the vertebral body are typical plain film findings for tuberculous spondylitis. Involvement of the adjacent intervertebral disk or
vertebral body results from penetration through the disk itself or spread of infection beneath the anterior longitudinal or posterior longitudinal ligament.\textsuperscript{36} Most common type of involvement seen in tuberculous spondylitis is paradiscal type.\textsuperscript{4} In the present study 94% patients had this type of involvement. Posterior type of involvement was seen only in 2% of the patients. These findings are comparable to those reported in the literature.\textsuperscript{4,52}

\textbf{iii. Other radiological findings}

Radiographic changes associated with TB spine include rarefaction of the vertebral end plates, disc space narrowing, anterior wedging and bone destruction, but these findings may not be visible on plain radiograph up to eight weeks.\textsuperscript{56,82} Various studies report that plain radiograph demonstrated changes consistent with spinal TB in 84\% to 99\% cases.\textsuperscript{92} In the present study 88\% of the patients showed radiographic changes consistent with spinal TB. Early lesions are usually missed on plain radiography because at least 30\% to 40\% mineral density should be lost before changes appear on radiographs.\textsuperscript{93} Baksh reported that diagnosis was reached in majority of cases (88.27\%) on plain radiographs, in the form of typical destructive lesions and pre-or paravertebral shadows.\textsuperscript{79} Table 22 shows comparison with the findings of the literature.

\begin{table}[h]
\centering
\begin{tabular}{|l|c|c|c|}
\hline
\textbf{Findings} & \textbf{Danchaivijtr et al (2007)}\textsuperscript{52} & \textbf{Al-Mulheim (2007)}\textsuperscript{56} & \textbf{Present study} \\
\hline
End plate destruction & 43.8\% & - & 88\% \\
\hline
Disc Involvement & 42\% & - & 90\% \\
\hline
Vertebral body destruction & 40.3\% & 25.5\% & 46\% \\
(Wedge/ Collapse) \\
\hline
Skip Lesion & - & - & 2\% \\
\hline
Posterior Elements & 5.7\% & - & 22\% \\
\hline
Soft Tissues & 31.7\% & 25.5\% & 58\% \\
\hline
Sclerotic Lesion & 31.5\% & - & 4\% \\
\hline
\end{tabular}
\caption{Other radiological findings}
\end{table}

In the tuberculosis, mineral loss and bony destruction prevails over repair. Once the disease process is halted, reparative changes can be identified in the form of end plate...
sclerosis and subsequently bony fusion may develop. End plate sclerosis was observed as early as six months in 8% of the patients, gradually progressing to 78% and 90% at 12th and 24th month respectively, in the present study. Fusion was observed in 8%, 66% and 76% of the patients at 6th, 12th and 24th months respectively. Decrease in the initial blurring/ ill definition of the end plate and decrease in soft tissues (abscesses) were the first signs of healing observed on the plain radiographs of the affected spine the present study. It took almost 3 month to 12 months for these signs to appear. Sclerosis, eburnation, severe narrowing of disc space, bony ankylosis, and osteophytosis are the features found in healed spondylitis. The radiological evidence of healing lags behind by three months. In the absence of reliable serological and immunological marker of healing, the ‘healed status’ is achieved if there is clinical and radiological evidence of healing with no recurrence after two years.

iv. Average number of vertebrae involved:

In the present study, at the initial presentation 2.06 average numbers of vertebrae were affected and these increased to 2.12 at subsequent follow up. Findings of the present study are consistent with other studies (Table 23).

<table>
<thead>
<tr>
<th>Authors</th>
<th>Year of study</th>
<th>Average no. of vertebrae affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mukhopadhya et al (1957)</td>
<td>1957</td>
<td>3.8</td>
</tr>
<tr>
<td>Martin et al (1970)</td>
<td>1970</td>
<td>3.4</td>
</tr>
<tr>
<td>Kim et al (1994)</td>
<td>1994</td>
<td>2.8</td>
</tr>
<tr>
<td>Present study (2012)</td>
<td>2012</td>
<td>2.06</td>
</tr>
</tbody>
</table>
v. **Deformity and vertebral body destruction:**

1. **Vertebral body height loss (VBL):**

   In the present study mean VBL observed was 0.26, 0.36, 0.45 and 0.7 at initial, 6, 12 and 24 months respectively. VBL was least in cervical and lumbar spine. It may be due to the biomechanical reasons as lordosis is normally present in these areas. Jain et al reported mean VBL of 0.77 (0.1- 2.0) in the group treated with ambulant multi-drug chemotherapy (Group A) and 0.67 (0.2-1.5) in patient treated surgically with anterolateral decompression (Group B). Initial VBL was found to be less than one in 59 patients (84%). Rajasekaran found the initial VBL of less than one in only 60% of his patients. In the present study we found initial VBL of less than one in 94% of the cases.

2. **Kyphotic angle:**

   In the present study mean kyphotic angles combined all sites observed were 2.26, 4.14, 5.48 and 5.64 at initial 6, 12, 24 months respectively. Initial kyphotic angles observed in dorsal and thoracolumbar spine was 18.6° and at 24 months was 30.1°. Jain et al reported pre-treatment angle of 24.3° (1-73°) and mean observed angle of 37.7° (8-81°) in patient with single spine lesion at level L₂ or above and treated with ambulant multidrug treatment; and a mean pre-treatment angle of 25.9° (7-84°) and mean observed angles of 26.8° (3-63°) in 30 patients treated by anterolateral decompression. Moon et al reported average kyphotic angles in lumbar spine of 4.2°, 4.6°, 4.4°, 2.3° and 8.6° at before treatment and at 3, 6, 12, 18 and 36 months after treatment; while in the present study values were -7.3°, -5.3°, -4.9° and -6.1° at initial, 6, 12 and 24 months respectively. In the present study normal lumbar lordosis was comparatively maintained. Upadhyay et al reported reduction in mean kyphosis in the thoracic spine from 31° preoperatively to 24° six months postoperatively, in radical group and this improvement was largely maintained into adult life. In debridement group it increases from 35° to 43° after surgery; this also remained practically unchanged, except in period from one to five years postoperatively, when these appeared to be a spontaneous correction at about 5°. In thoracolumbar spine radical group showed a mean reduction of 5° in kyphosis six month after surgery, whereas debridement group showed a mean increase of 11°. In lumbar lordosis normal condition was maintained with a mean decrease of 1°-2° at 6, 12 and 24 months postoperatively.
spine, mean preoperative kyphotic angle in the radical group was 9° of lordosis; it did not change after surgery, and at final follow up the mean lordosis was 14°. By contrast, the debridement group changed from a mean preoperative lordosis of 4° to a mean kyphosis of 4° at six months, and to 6° at final follow up.98

Similar to the observation of Jain et al kyphotic angle achieved at 6 months was not maintained at 24 months follow up in the present series also.97 Fifteen patients (78.9%) of thoracic and thoracolumbar junction area showed increase in kyphotic angle, 17 patients (89.4%) showed increase in deformity angle. The increase in deformity angle was extremely significant between initial and 6 months (p value 0.0006); 6 and 24 months (p value 0.0009). Increase in kyphotic angle was also statistically significant between initial and 6 month (p value 0.0037); and 6 and 24 months (p value 0.0001). Upadhyay et al reported statistically significant difference only in preoperative values and 6 months (p value 0.0001). There was no statistically significant deformity angle (p value< 0.0001).98

In the lumbar spine only eight (40%) showed increase in kyphotic; and eleven patients (55%) showed increase in deformity angle. This increase in kyphotic angle was not statistically significant between initial and 6 months and 24 months. Increase in deformity angle was significant only between initial and 6 months. Upadhyay et al reported significant difference in both kyphotic angle (p value 0.0001) and deformity angle (p value < 0.001) between preoperative and 6 months values.98 Similar to the observations of the present study they also did not find any statistical difference subsequent.98

Similar to Moon et al we found that pattern of vertebra body collapse in lumbar spine was different from the thoracic spine, and that little kyphosis was complicated as a sequel at the time of healing of TB.2 Rajasekaran et al reported that the presence of normal lumbar lordosis seemed to alter the pattern of collapse. In the dorsal and dorsolumbar lesion with vertebral destruction, acute kyphosis developed until there was contact of healthy vertebrae.1 Generally in the past, it was considered that the pattern of vertebral body collapse in spinal TB is the wedge-shaped one, which leads to kyphosis of
the spine. However, it was found that the pattern of the vertebral body collapse in TB was vertical (telescoping) in patients who were treated.\textsuperscript{1,99}

Puig Guri experienced that the collapse in TB spondylitis can occur along a longitudinal axis (telescopy) or by flexion in the sagittal plane of one spinal segment on the other (inflexion). In the lumbar region, because of the larger size of the disc, the vertical position of the articular facets and the relative narrowness of the pedicle, a marked amount of telescoping was possible. In the thoracic spine, because of the more horizontal orientation of the articular facets, subluxation follows destruction of the anterior structures leading to an angulatory collapse.\textsuperscript{100}

It had also been previously reported that patients who had a lesion of the thoracic spine had more progression in the angle of kyphosis than did those who had a thoracolumbar lesion, with the least increase occurring in patients who had a lumbar or a lumbosacral lesion.\textsuperscript{1,2,41,81,85,86}

3. Correlation between the observed final angle and initial vertebral body height loss (VBL):

In the literature it had been observed that initial VBL and final kyphotic angle showed a correlation.\textsuperscript{40} In the present study we could not find such a correlation ($r = 0.302; \ p > 0.05$) (Graph 9). Jain et al reported that in the conservative group initial VBL and the observed final angle had better correlation than in the operative group.\textsuperscript{97}

4. Deformity angle:

In the present study mean deformity angles were 12.5, 16, 17.1 and 17.8 degrees at initial, 6, 12 and 24 months respectively for all the patients. Moon et al reported that average deformity angle in the lumbar spine before treatment and at 3, 6, 12, 18 and 36 month after treatment were 6.2, 7.2, 7.9, 8.2, 8.4 and 8.6 degrees respectively.\textsuperscript{2} These values were less compared to the values observed in the lumbar spine in the present study. There was an increase in deformity angle at various sites of vertebral column in the present study except at cervical spine at subsequent follow-ups. Mean increase in deformity angles of 5.3, 8.3, 13.7 and 1.2 were observed in the whole series, dorsal, thoracolumbar and lumbar spine respectively. Upadhyay et al in the children reported that
Graph 9: Correlation between VBL and final kypotic angle.

$r$ value = 0.302; $p > 0.05$

The equation of the line is $y = 11.25x + 24.59$ with $R^2 = 0.091$. The correlation is positive, indicating a weak linear relationship between VBL and final kypotic angle.
mean change in deformity angle in thoracic spine in the first six months was statistically significant between radical and debridement groups; the radical group improved, while debridement group deteriorated. They found no difference for other periods of follow-up. In thoracolumbar spine they reported that deformity angle reduced by 7° in the radical group six month postoperatively, but debridement group had a mean increase of 11°. From six month to one year, radical group had a mean increase of 5° and than little change to final follow-up. The debridement group again showed spontaneous correction of deformity angle by a mean of 8° from 6 month to final follow-up. In the lumbar spine they reported mean preoperative deformity angle of 10°, reducing to 7° at six months and 4° at final-up in radical group; while mean preoperative deformity angle was 20°, which increased to 37° at one year and improved only to 21° at final follow-up.98

5. Lumbosacral joint angle:

The average lumbosacral joint angles observed were 12.3, 12.1, 10.8 and 10.8 degree at initial, 6, 12, and 24 months, respectively in the present study. Moon et al reported 32°, 30°, 28°, 26°, 26° and 26° lumbosacral joint angle at pre-treatment and 3, 6, 12, 18 and 36 months after treatment.2 In both the studies lumbosacral joint angles did not show any change after 12 months.

Moon et al reported that patients with TB of the lumbosacral joint also could be treated successfully with minimal changes of the lumbosacral joint angle. Even in patients with a decreased lumbosacral joint angle with or without fusion (secondary sacralisation of L5), an upper normal joint could compensate for the loss of lumbosacral joint motion by developing hyperlordosis.2 Rajasekaran et al reported the phenomenon of subsidence in lower lumbar lesions, in which the superior vertebra gradually descended without kyphosis. Here the inferior surface of the superior vertebra and the superior surface of the inferior vertebra came into contact, with loss of normal lordosis but without kyphosis.1

E. MAGNETIC RESONANCE IMAGING:

Multiplanar capability and superior tissue contrast make MRI the modality of first choice in the evaluation and follow-up of spondylodiscitis. A major advantage of MRI,
compared with CT scan and plain radiography, is the higher sensitivity for detection of early inflammatory bone marrow changes in the vertebra. MR imaging is mostly useful in delineating paravertebral, epidural and intraosseous abscesses; and in evaluating the extent of cord compression and presence of intramedullary lesions. Various MRI features observed in the present study are discussed below and compared with the literature.

a. MRI findings at presentation:

i. Signal intensity:

At MRI, the occurrence of diffuse signal intensity alterations in patients suffering from chronic bacterial infectious spondylitis are probably caused by reactive bone marrow stimulation. The decreased signal intensity of T1-weighted images probably result from a replacement of fat cells by non-neoplastic stimulated, proliferating bone marrow cells producing white blood cells. The reaction parallels the process of stimulation of hematopoiesis (red cells). Osteitis was seen as low signal intensity on T1W images and high signal intensity on T2W images. On T1W images all the patients (100%) showed hypointense signal intensity. On T2W images 49 patients (98%) showed hyperintense signal intensity and only one patient (2%) showed mixed signal intensity. On STIR images 48 patients (96%) showed hyperintensity and only 2 patients (4%) showed isointense signal intensity. Al-Mulhim et al reported decreased signal intensity on T1W images in 13 vertebrae (46%), and mixed signal intensity in 9 (32%). Signal intensity on T2W images was isointense or mixed in 9 (32%) vertebrae each and hyperintense in 5 (18%) vertebrae. Liu et al reported signal intensity of involved vertebrae hypo on T1W images in 22 cases (75.8%); while the remaining 7 cases (24.2%) had an intermediate T1-signals. All the 29 cases (100%) had high T2-signal intensity.

ii. Contrast enhancement:

Contrast MRI done in 20 patients showed enhancement of the lesions in the present study. Liu et al reported contrast enhancement in 10 patients. Two cases demonstrated canal involvement by necrotising granuloma, not visible on T2W images.
Al-Mulhim et al gave contrast in 20 lesions. Fourteen lesions showed enhancement. All the vertebrae with decreased signal intensity on T1W images showed post-contrast enhancement, two-third of isointense lesions also showed enhancement. Andronikou et al assessed enhancement characteristic in 20 children. Sixty-five percent of these showed ring enhancement of soft-tissue mass, while 39% showed patchy/speckled enhancement and 12% showed diffuse homogenous enhancement. All the patients showed bone enhancement. They suggested that this feature could assist in early detection of disease confined to bone and will differentiate infection from bone edema.

iii. Pattern of vertebral body involvement:

Moorthy and Prabhu described four patterns- Paradiscal lesions adjacent to the intervertebral disc with associated disc narrowing, anterior subperiosteal lesions with spread under the anterior longitudinal ligament over multiple levels, central lesions without disc involvement leading to vertebral collapse often mimicking lymphoma or metastasis, and finally posterior involvement.

Paradiscal involvement was observed in 92%, anterior in 2%, central in 4% and posterior appendicular in 2% of the cases in present study. Paradiscal lesions are the most common pattern of spinal TB, and this was also observed in present series. Tuberculosis of the posterior element is considered rare. Kumar suggested that nearly 5% of spinal TB could be located in the posterior element. Recognition of posterior element involvement is important in TB, because successful treatment requires laminectomy in addition to chemotherapy. It is also important to differentiate it from metastasis to the spine.

iv. Associated posterior element involvement:

Associated posterior element involvement was observed in 15 patients (30%) in the present study. Desai et al, Al-Mulhim et al, Loke et al, and Narlawar et al reported posterior element involvement as 8%, 68%, 40% and 24% respectively in their studies. Simultaneous involvement of the anterior and posterior elements leads to spinal instability. Most anterior fixation devices depend on intact posterior elements and are inappropriate in cases of posterior element TB.
**v. Number of vertebrae involvement:**

On MR imaging 119 vertebrae were involved in the study population comprising 50 patients. The average number of vertebrae affected per patient was 2.18. Kim et al\textsuperscript{75} and Al-Mulhim et al\textsuperscript{56} reported average number of affected vertebrae per patient as 2.8 and 2.3 respectively. With the advent of newer imaging techniques that enable the early detection of TB the average number of affected vertebrae is on declining trend. In earlier studies conducted by Mukopadhyay et al\textsuperscript{95} and Martin\textsuperscript{96} the average numbers of affected vertebrae were 3.8 and 3.4 respectively.

**vi. Pattern of vertebral involvement:**

Involvement of contiguous vertebrae (2 or more) was seen in 47 (94\%) patients in the present study. This observation was in concordance with those of Liu et al\textsuperscript{73}, Kim et al\textsuperscript{75}, Loke et al\textsuperscript{105} who reported contiguous vertebral involvement in 93\%, 95\% and 80\% of the cases respectively.

Contiguous involvement of 3 or more vertebrae was observed in 18\% of the cases in the present study. This observation was similar to that of Liu et al\textsuperscript{73} who reported incidence of such involvement to the extent of 17.25\%. Kim et al\textsuperscript{75} and Loke et al\textsuperscript{105} reported a higher incidence of contiguous involvement in 3 or more vertebra to the extent of 36.3\% and 47.6\% respectively.

On MR imaging single vertebral involvement was seen in 4\% patient in present study. Liu et al\textsuperscript{73}, Loke et al\textsuperscript{105} and Lolge et al\textsuperscript{107} found single vertebral involvement in 7\%, 7.3\% and 1.7\% of patients respectively. Single vertebral affection without involvement of disc is not a well-recognized entity and is often misdiagnosed and mistreated. These isolated single vertebral involvements are considered to be an earlier stage of TB spondylitis.\textsuperscript{73} The low incidence of single vertebral involvement in the various studies is more likely due to delayed presentation of patients when disease is well advanced and it involves adjacent vertebral bodies and intervertebral disc. In a study conducted by Desai et al\textsuperscript{47}, they found single vertebral involvement in 50\% of subjects. This abnormal high value was because of the patient had undergone bone scan before MRI. One of the two patients in the present study had 2vertebral involvement at six
month MRI; it means early MRI at initial stage of the disease was done. Another patient had PET scan in addition to MRI to pick early lesion at fifth lumbar vertebra.

**vii. End plate destruction:**

Destruction of end plate is considered typical for disc infection.\(^22,\)\(^67\) It was observed in 45 patients (90\%) at the time of presentation. However, some authors reported intact end plate on both sides of infected disc and lack of end plate involvement can therefore not be used as reliable sign to exclude spinal infections.\(^54,\)\(^70\)

**viii. Disc involvement:**

Discitis is seen as increased signal intensity on T2-weighted images. In the present study disc involvement was seen in 90\% of the cases. The reported incidence of disc involvement was seen in 90\% of the cases. The reported incidence of disc involvement varies from 33\% to 95\% (table 24).\(^47,\)\(^51,\)\(^56,\)\(^60,\)\(^61,\)\(^73\)

<table>
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<tr>
<th>Author</th>
<th>Percentage of patients with disc involvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liu et al 1993 (^73)</td>
<td>72%</td>
</tr>
<tr>
<td>Desai et al (1994)(^47)</td>
<td>33%</td>
</tr>
<tr>
<td>Al-Mulhim et al (1995)(^56)</td>
<td>46%</td>
</tr>
<tr>
<td>Jung et al (2004)(^60)</td>
<td>55%</td>
</tr>
<tr>
<td>Cormican et al (2006)(^51)</td>
<td>95%</td>
</tr>
<tr>
<td>Page et al (2006)(^61)</td>
<td>73.6%</td>
</tr>
<tr>
<td>Present study (2012)</td>
<td>90%</td>
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</table>

The feature that most clearly distinguishes spinal TB from pyogenic osteomyelitis is relative sparing of the intervertebral disc. Mycobacteria lack the proteolytic enzyme found in bacteria that commonly cause pyogenic osteomyelitis, and this may be responsible for the relative sparing of the disc.\(^91\) The avascularity of the disc may prevent them from serving as an initial site of infection, and it has been suggested that disc
destruction begins only when two adjacent vertebral bodies are so involved that the disc loses its nutritional support.\textsuperscript{24} In some cases, apparent loss of disc height is actually due to herniation of the disc into a partially destroyed vertebral body.\textsuperscript{46,103} The narrower disc space in TB spondylitis is distinct from degenerative disc disease because it has a high T2-signal intensity due to infectious character instead of the dehydrated, low T2-signal intensity in degenerative disc disease although type I degenerative disc may show a slightly elevated T2-signal intensity.\textsuperscript{91}

ix. Bone marrow edema:

Edema on vertebral bodies was observed on initial MRI in all the patients. Page et al also observed edema in all the cases initially.\textsuperscript{61}

x. Pre and paravertebral collection:

Pott's disease can be distinguished by its characteristic paravertebral abscesses. The extent of these collections may greatly exceed the area of osseous involvement. Paravertebral abscesses were present in 90\% of the cases with total spread of 138 vertebral levels. Average vertebral extent of soft tissue collection was 3 vertebrae. Psoas abscesses were seen in 9\% (18\%) patients. Enhancement was seen in all the cases in whom gadolinium was administered, but we were not able to demonstrate any calcification in these abscesses on MRI. The wall of the abscess is characteristically thick and irregularly enhanced on MRI, and these feature thought to be diagnostic of tuberculous spondylitis.\textsuperscript{34} Reported incidence of paravertebral abscess is between 58\% to 100\% (table 25).\textsuperscript{45,56,60,61,63,75}

<table>
<thead>
<tr>
<th>Author</th>
<th>Percentage of patients with paravertebral abscess</th>
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<tr>
<td>Kim et al 1994\textsuperscript{75}</td>
<td>100%</td>
</tr>
<tr>
<td>Al-Mulhim et al (1995)\textsuperscript{56}</td>
<td>71%</td>
</tr>
<tr>
<td>Loke et al (1997)\textsuperscript{105}</td>
<td>73.3%</td>
</tr>
<tr>
<td>Jung et al (2004)\textsuperscript{60}</td>
<td>95%</td>
</tr>
<tr>
<td>Yusof et al (2006)\textsuperscript{63}</td>
<td>58%</td>
</tr>
<tr>
<td>Page et al (2006)\textsuperscript{61}</td>
<td>100%</td>
</tr>
<tr>
<td>Andronikou et al (2002)\textsuperscript{45}</td>
<td>98%</td>
</tr>
<tr>
<td>Present study (2012)</td>
<td>90%</td>
</tr>
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</table>
Subligamentous spread occurs when infection spreads beneath anterior longitudinal ligament and periosteum. There is relative preservation of intervertebral disc space. Radiologically it manifest as erosion of anterior surface of vertebral body. In the present study subligamentous spread was seen in 42 (84%) of the patients with total spread over 108 vertebral levels. Average vertebral extent of subligamentous spread per patient was 2.57. Loke et al, Jung et al, and Andronikou et al subligamentous reported in 66.6%, 85% and 64% of the cases respectively.

Epidural collection in the present study was observed in 26 (52%) patients with total vertical extent of 77 vertebral bodies. Various studies have reported incidence of epidural abscess between 53.3% to 82% (table 26).

Table 26
The reported incidence of epidural collection in the literature

<table>
<thead>
<tr>
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<th>Percentage of patients with epidural collection</th>
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<tbody>
<tr>
<td>Al-Mulhim et al (1995)</td>
<td>60.7%</td>
</tr>
<tr>
<td>Loke et al (1997)</td>
<td>53.3%</td>
</tr>
<tr>
<td>Page et al (2006)</td>
<td>82%</td>
</tr>
<tr>
<td>Present study (2012)</td>
<td>52%</td>
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</tbody>
</table>

xi. Intracanalicular involvement on MRI

Following intracanalicular findings were observed: extradural component (caseous/granulation tissue) in 33 (66%), canal encroachment in 14 (28%), nerve root involvement in 3 (6%), cord signal intensity change and intradural abscess in 1 (2%) case each. Percent canal encroachment was 19.2% (range: 10-40%). Spinal column translation and impingement was seen in 1(2%) cases. Page et al reported spinal cord compression in 64% and radicular compression in 36% of the cases. The precise level of cord compression was responsible for neurological deficit. Hoffman et al in pediatric population with tuberculous spondylitis showed that all patients had more than 50% compression of the spinal cord. Extradural component was present in 33 patients (66%),
but only 11 patients (22%) develop neurological deficit in the present study. This is because not all cord compressions lead to neurological deficit. Compression of 60% or more above the level of conus medullaris, resulted in neurological deficit, while compression below the conus level resulted in no neurological sign.\(^4\) Cormican et al reported MR evidence of spinal cord compression, of cauda equina compression, and of radicular disease in 13 (65%), 2 (10%), and 2 (10%) patients respectively.\(^5\) Two had evidence of a myelopathy (both spinal cord compression). However, only 4 had an evidence of suggested neurological deficit on clinical examination. Andronikou et al reported that cord was abutted on in 85% and compressed in 79% of their patients by soft-tissue mass projecting into the spinal canal. In 67% of patients with axial imaging, the thecal sac was completely obliterated.\(^6\) Focal myelopathy presenting as an increased signal of the cord on T2W-l images had been noted in adults and was thought to indicate a poor prognosis.\(^7\) Andronikou et al reported 4 patients with focal myelopathy demonstrated by high T2W-signal within cord.\(^8\) High signal intensity within cord could be either cord edema or myelomalacia. Edema is reversible, but unfortunately myelomalacia is not. Therefore clinical history and duration of disease has to be considered for the same.\(^9\)

As the initial contrast MRI was done in only 20 cases, we could not appreciate meningeal involvement, nerve root clumping, arachnoditis etc in majority of cases in the present study. Epidural extension and meningeal involvement are seen to better advantage on enhanced MR examinations.\(^10\)

\(\text{xii. Combination of various MRI findings}\)

Various classical features of the tuberculosis of the spine in combination on MRI can be used with confidence diagnose it. Ninety-two percent cases had combination of marrow edema and paravertebral collections. Eighty-eight percent cases had a combination of marrow edema and subligamentous spread of disease. Eighty-two percent cases had combination of marrow edema, paravertebral collections and end plate erosion. Eighty percent cases had combination of marrow edema, paravertebral collections, end plate erosion and subligamentous spread. Fifty-two percent cases had a combination of
subligamentous spread and epidural abscess. Sixty-six percent cases had a combination of subligamentous spread and extradural component (caseous/ granulation tissue) suggestive of spread anterior and posterior to vertebral body. Sixty-four percent cases had combination of marrow edema, paravertebral collections, subligamentous spread, extradural component, end plate erosion and discitis. A combination of marrow edema, paravertebral collections, end plate erosion and subligamentous spread on MRI present in majority of the cases (88% of cases) are the classical features of the TB spine. We are not aware of any study in the literature reporting such combinations on MRI to increase sensitivity and specificity of the MRI in the diagnosis of tuberculosis of the spine.

b. MRI findings at follow-up:

Reversal of signal intensity changes were observed in follow-up MR examination. Hyperintense signal intensity was seen on T1W- images in 5 (10%), 21 (42%), and 42 (84%) of the patients at 6, 12, and 24 months MR images respectively. STIR images showed hyperintense signals in 47 (94%), 26 (52%), and 12 (24%) of the patients at 6, 12, and 24 months MR images respectively. Forty-six percent patients at 12 months and 74% at 24 months showed suppression of signal intensity on STIR images. Increased signal intensity on T1W-images from previously affected vertebrae indicates healing and has been found to correlate well with clinical signs and symptoms. Sharif et al reported reversal of signal intensity on T1W-images of previously infected vertebrae in 12 of 25 patients who underwent follow-up examination 1-12 months after the initial examination. They also reported a gradual decrease in signal intensity of the affected spinal region on T2W-images in all the patients. They reported that the longer the follow-up, the less abnormal the signal intensity. similar observation was also made in the present study.

Bone marrow edema decreased with passage of time. At six months MR images of 10 patients (20%) showed increased and 38 patients (76%) showed decreased in vertebral body edema. At one year MR images it was decreased in 50% and absent in other 50% of the cases. Page et al reported conversion of initial edematous of the vertebral body gradually to fatty signals in 40% cases at six months and 75% at 12
months. This change (increase in T1W-signal intensity is a sign of cure. Sharif and co-workers reported conversion to a fatty signal in 48% of cases at one year.55

Total number of vertebral involvement was 119, 117 and 115 with average vertebral involvement per person as 2.18, 2.38, and 2.3 at initial, 6, 12, and 24 months. There was significant increase in the vertebral involvement in the first 6 months, although incidence of disc involvement remained fairly constant. Paravertebral abscesses showed steady decline in incidence and size. It was the first sign of healing observed on MRI in the present study. Although 13 (26%) and 1 (2%) of the patients showed paravertebral abscesses at the end of 12 and 24 months respectively. Similar observations were also made in regard to subligamentous spread and epidural abscesses. Only 10 (20%) and 4 (8%) patients showed subligamentous spread and epidural abscesses respectively at 12 months. None of the patients had these involvements at the 24 month follow-up MR images.

Page et al reported that paravertebral abscesses regressed in 45% of cases at 2 months, 50% at 6 months, and 85% at 12 months. Epidural abscesses regressed in 50% of the cases at 3 months, 90% at six months, and 100% at 9 months. Many lesions remained visible on MR images at the end of treatment (15% of initial paravertebral abscesses and 25% of vertebral edematous signals) despite the favorable clinical outcome with mean follow-up of 25 months. Cormican et al reported that MR examination performed between 6 and 12 months showed persistent disease activity in 5 of 10 (50%) patients. The changes found were suggestive of infective discitis in 3, vertebral body abscess in one, and vertebral body edema in one. Multi-focal intraosseous abscess with persistent cord compression was found in one patient. Sharif et al reported decrease in size of abscess seen in all 25 patients in the follow-up MR examination 1-12 months after the initial examination. Follow-up MRI was performed in 16 out of 53 children between 2 months to 13 months of initial MR examination by Andronikou et al. They reported progression of kyphosis in two, progressive bone destruction in 10, and soft-tissue mass size decrease in 6 and increase in one.
Healing of spondylitis is associated with long standing signal alterations on MR imaging, even if there is no clinical evidence of persistent infection. The earliest sign of healing is a reduction of the thickness of the inflammatory tissue mass. A high signal intensity rim on T1W image at the edge of lesion represent healing. Although useful when seen, this is a relatively late occurring sign, seen at a mean of 15 weeks. Decrease in bone marrow edema and soft-tissue mass were the earliest sign of healing observed on the MRI in the present study. It was also observed that the marrow edema increased in 20% of the patients and average vertebral involvement per person increased to 2.38. It has been reported that during healing phase imaging evidence of bone destruction can progress up to 14 months, and recovery of vertebral height may not be seen earlier than 15 months after starting treatment. Thus progression of bone destruction while on therapy should not necessarily be considered a sign of treatment failure. Paravertebral soft-tissue masses reach a maximum size within 2 months of presentation and can take up to 15 months to resolve. Gilliams et al also reported that progression of bone or disc changes with an alteration in signal intensity or increased destruction does not indicate failed treatment. Progressive reduction in Gadolinium enhancement and eventually disappearance of all enhancements are useful sign of healing. Increasing or persisting Gadolinium enhancement can be seen concomitant with clinical improvement, however, and does not necessarily indicate treatment failure.

Reduction in extradural component was observed on the subsequent follow-up MR images. It was observed in 25(50%), 6 (12%), and 2 (4%) of the cases at 6, 12 and 24 months. Significant improvement in extradural compression which correlated with clinical response was reported by Hoffman et al in 5 patients who had a follow-up MRI.

There was increase in percent canal encroachment and spinal column translation & impingement on subsequent follow-up MR images. Cord signal intensity change and spinal cord changes also increased in 5(10%), 7(14%), and 6(12%); and in 2(4%), 4(8%), and 5(10%) cases on 6, 12, and 24 months MRI respectively.

Jain et al reported that extradural compression attributable to fluid on MRI scans resolves well with treatment and patients have good recovery in comparison with
extradural compression with mix or granulomatous (dry) nature showing constriction of cord. Patients with reserved cord volume with edema and myelitis of the cord on MRI scans have a good neural recovery. Myelomalacia of the spinal cord was found to be a poor prognostic sign of neural recovery. The magnitude of thinning of the cord did not always correlate with severity of neurological deficit; however, thinning of the cord is associated with myelomalacia, syrinx, or both carry a bad prognosis.

In long standing compression, some permanent changes in the cord may be responsible for non recovery or poor recovery. This was also observed in the present study (cases no 29.).

There is no guidance on appropriate imaging modality and frequency of use in the follow-up of spinal TB. Follow-up in MRC trials is based on plain film radiology of the spine. Although the MRC trials have shown persistent changes on plain radiological appearances of vertebral column up to 3 years after completion of treatment, these changes were attributed to new bone formation and ankylosis. Self limiting abscesses have been described in MRC series affecting up to 8% patients. These however resolved within six months of chemotherapy. In the present study also plain film radiology has shown its utility in diagnosis, treatment and subsequent follow-ups. We were able to appreciate radiological features consistent with spinal TB in 88% of the patients at the time of initial presentation. Earliest sign of healing observed was decrease in soft-tissue size, followed by end plate sclerosis and fusion. Earliest sign of bone healing was decrease in fuzziness of end plate leading to sclerosis (78% and 90% at the end of 12 and 24 months of treatment).

We agree with Cormican et al that there is no guidance on soft-tissue or vertebral changes noted on MR spine examination, during the course of, or after antitubercular therapy. These days more emphasis is on short-course chemotherapy (6 months) for adult uncomplicated fully sensitive TB. Moreover similar to the study by Cormican et al present study also presents that in significant proportion of the patients, longer duration of treatment may be required as their MR scans were abnormal even though there was apparent disease resolution clinically.
In the light of the above discussion, we conclude that delay in diagnosis, treatment and chronic nature of the disease result in spinal tuberculosis as one of the leading cause of backache and deformity of the spine in India. ESR is of good prognostic value in monitoring the disease progress and drug response. Salient features of spinal involvement in TB on plain radiograph are paradiscal involvement, end plate destruction and soft tissue masses. Earliest sign of healing on plain radiography is decrease in fuzziness of end plate ultimately leading to either sclerosis of end plate or fusion of adjacent vertebrae. MRI serves as an important diagnostic tool in early diagnose the disease, to see the response to the chemotherapy, and to decide the need for the surgery and approach to be used. Decrease in inflammatory soft-tissue masses and reduction in vertebral body marrow edema are the earliest feature of healing observed on MR examination. We observed that increase or decrease in marrow edema, paravertebral collections, subligamentous spread, extradural component, end plate erosion and discitis are the prognostic indicators of response to the chemotherapy. We highlight that short-course chemotherapy (6 months) may not be effective in completely curing the spine TB as evidenced by the clinical, laboratory, plain radiography, and MRI parameters evaluated in the present study. In a patient who has a favorable outcome as depicted by clinical improvement and normalization of the markers of the inflammation; persistence of small amount of MRI abnormalities even after 12 months of chemotherapy are inconsequential. We propose a protocol of MR examination at presentation, 6, 12, and 24 months should be followed for diagnosis and monitoring the disease course. This study will be continued in the future also to see the long term clinico-radiologic profile of these patients with further enrolment of new cases.