Isolated Transverse Process Fractures: A Systematic Analysis

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Key words
- Review
- Spine trauma
- Transverse process fractures

Abbreviations and Acronyms

ITPF: Isolated transverse process fracture
MVA: Motor vehicle accident
TPF: Transverse process fracture

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OBJECTIVE: **To review the literature on isolated transverse process fractures (ITPFs) and provide evidence for the current practice of conservative management.**

METHODS: **The PubMed database was searched for published literature related to ITPFs. Baseline patient (age, sex, presentation, and mechanism of injury) and fracture (number of fractures, level, and single or multisegmental) characteristics were extracted. Management and outcomes were also recorded. Statistical comparisons were ascertained through n−1 Pearson χ^2 tests.**

RESULTS: **A total of 4 studies comprised of 398 patients with 819 ITPFs were evaluated. Mean age was 33.5 years (69% men and 31% women). No patients presented with neurologic deficits. The most common mechanism of injury was motor vehicle accident (MVA), followed by fall. MVAs were more commonly the cause of ITPFs in pediatric versus adult patients (88% vs. 65%, respectively; $P = 0.0001$). Falls were more commonly the cause of ITPFs in adults than in children (18% vs. 9%, respectively; $P = 0.05$). Management strategies involved unrestricted movement, bracing, and orthotics. Radiologic evidence of spinal instability or deformity was not reported in any of the cases. Mean follow-up was 20.5 months.**

CONCLUSIONS: **Our data suggests that nonsurgical management of ITPFs leads to complete resolution of the fracture without evidence of permanent neurologic deficit or spinal instability. However, interpretation of our results is limited by the paucity of meaningful literature reporting on long-term outcomes. Nevertheless, the results provide support for conservative management and highlight the existing need to identify markers or scenarios where the diagnosis of ITPF is actually likely to be erroneous.**

INTRODUCTION

Isolated transverse process fractures (ITPFs) of the spine were once thought to be rare.[1-3] However, recent studies suggest that misdiagnoses of ITPFs on plain radiographs occur in as many as 11% of patients undergoing evaluation after trauma to the spine.[4] Increased resolution and utilization of computed tomography have improved sensitivity in the detection of ITPFs (**Figure 1**).[3,5-9] The term isolated describes the absence of other fractures within the involved vertebra. Although these fractures do not extend into lamina, pedicle, or facets, they may involve multiple segments (**Figure 2**). ITPFs are considered stable fractures that generally do not require surgical intervention. It is common practice to recommend nonoperative treatment, with some institutions having mandated a no neurosurgical consult policy for patients with ITPFs. Conservative measures typically include pain management and orthotics, with unrestricted mobilization as tolerated. Additionally, a collar, brace or corset may be recommended for comfort.[3,5,10,11]

The National Emergency X-Radiography Utilization Study criteria and Canadian C-Spine Rule categorize cervical ITPFs as insignificant fractures that do not require stabilization or follow-up imaging.[12-14] A caveat is an ITPF extending into cervical transverse foramina, which has the potential to injure enclosed vertebral arteries. Current management of ITPFs is largely based on clinical acumen, rather than evidence.[11] To date, only 4 publications detail the management of ITPFs; only 2 report follow-up and outcomes data. The authors of this study performed a comprehensive review of the published literature on ITPFs to provide evidence for and validate the current practice of conservative management.

METHODS

Search Strategy

The PubMed database was searched for literature published between the years 1975 and 2016. Peer-reviewed articles related to ITPFs) were identified using a strategic combination of search terms: *isolated transverse process fracture(s)* OR *transverse process spine fractures*. All identified titles and abstracts were screened for relevance by the independent authors (T. T. Bui and C. Lagman).

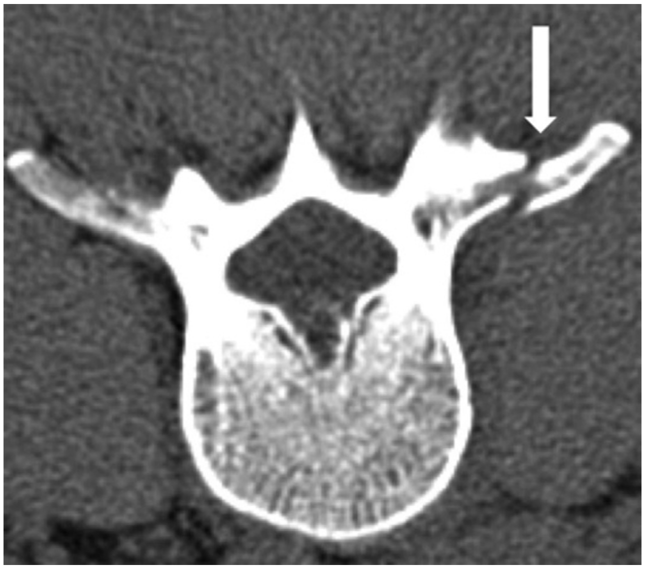

Figure 1. Axial computed tomography scan of right-sided L2 isolated transverse process fracture (*arrow*).

Study Selection

English full text articles reporting on original data regarding the management of ITPFs were included. Non-English articles, review articles, and studies deficient in outcomes data were excluded. Limits on age and sample size were not enforced. A total of 210 articles were screened. Nineteen articles passed the initial evaluation, and all available full texts were reviewed. Fifteen articles were deemed irrelevant (e.g., not specific to ITPFs) and were excluded from further review. The remaining articles were assessed for data extraction eligibility.

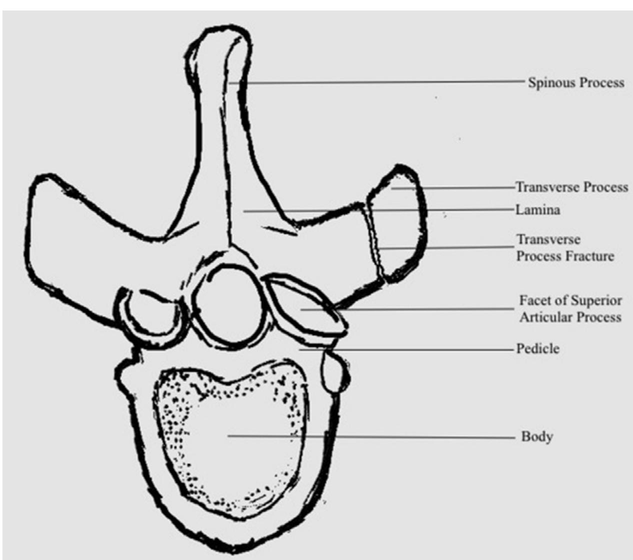

Figure 2. Illustration of a right-sided isolated transverse process fracture and corresponding bony landmarks in a lumbar vertebra.

Data Extraction and Synthesis

Data on sample size, mean age, sex, presentation, mechanism of injury, level, extent of involvement (i.e., single or multilevel), the number of fractures, management, and outcomes, were extracted (Table 1). Data, collated from individual articles, were analyzed using n−1 Pearson χ^2 tests to compare proportions.[15,16] Statistical significance was defined as a P value <0.05. Individual studies were not at risk of bias as assessed by the Risk of Bias in Systematic Reviews assessment tool.[17]

RESULTS

A total of 4 articles comprised of 398 (316 adults and 82 pediatrics) patients were included in the quantitative synthesis. The mean age of all patients identified was 33.5 years (adult patients mean age, 38.1 years and pediatric patients mean age, 15.5 years). There was, on average, an observed male predominance (approximate ratio, 2.2:1; range, 1.5:1–2.6:1), which held true for both adult and pediatric patients (2.4:1 and 1.7:1, respectively). However, these differences did not achieve statistical significance.

Neurologic deficits were neither noted at the time of injury, nor at the end of follow-up, for any patient. Associated system injuries (71%), generalized pain (43%), and spinal pain (28%) were common. The most common mechanism of injury was motor vehicle accident (MVA) at 70% (range, 43%–88%), followed by fall at 16% (range, 9%–29%). MVAs were more commonly the cause of ITPFs in pediatric versus adult patients (88% vs. 65%, respectively; $P = 0.0001$). Falls were more often the cause of ITPFs in adults than in children (18% vs. 9%, respectively; $P = 0.05$).

Single level ITPFs were less common than multilevel ITPFs (48% vs. 52%, respectively). Management consisted of unrestricted movement as tolerated (80%; range, 73%–100%), with braces or orthotics for comfort (18%; range, 0%–27%). No radiologic evidence of spinal instability or deformity were encountered

Table 1. Literature Review of Patients with Isolated Transverse Process Fractures

Study	Number of Patients	Mean Age (years)	M (n)	F (n)	Presentation	Mechanism	Level	SL/ML	No. of fx	Sx (Y/N)	Non-Sx Treatment	F/U (mean)	Outcomes
Akinpelu et al., 2016[10,*]	82	15.5	52	30	NND, 95.1% other injuries	MVA (88%), fall (9%)	T, L	SL (57%), ML (43%)	164	N	None (87%), brace (9%), collar (5%)	Clinical F/U (84%), 19 months; radiologic F/U (26%)	100% neurologically intact at F/U; no radiologic evidence of spinal instability, deformity, or treatment failure
Schotanus et al., 2010[11]	21	18.4	15	6	—	MVA (43%), fall (29%)	C	SL (90%), ML (10%)	25	N	None (100%)	Clinical and radiologic F/U (67%), 27.6 months	Mean patient satisfaction score 9.3/10, cervical ROM normal in all planes, Neck Disability Index score normal; stable and intact subaxial cervical spine on radiography
Bradley et al., 2008[5]	47	38.9	28	19	NND, 43% pain, 28% spinal pain, 30% abdominal injury	—	C, T, L	SL (36%), ML (64%)	60	N	None (100%)	—	—
Homnick et al., 2007[3]	248	37	179	69	—	MVA (67%), fall (17%)	T, L	SL (44%), ML (56%)	570	N	None (73%), corset (23%), brace (4%)	—	—
Total, n (%)	398	31.8	274 (69%)	124 (31%)	—	—	—	SL (48%), ML (52%)	819	N	None (80%), corset (14%), brace (3%), collar (1%)	20.5 months	—

M, male; F, female; Sx, surgery; fx, fractures; Y, yes; N, no; F/U, follow-up; NND, no neurologic deficit; MVA, motor vehicle accident; T, thoracic; L, lumbar; SL, single level; ML, multilevel; —, not reported; C, cervical; ROM, range of motion.
*Five patients with isolated spinous process fractures.

in the cases we reviewed. The mean follow-up duration was 20.5 months.

DISCUSSION

The authors of this study reviewed the current published literature regarding the presentations, managements, and outcomes of patients presenting with ITPFs. ITPFs are very common in the setting of trauma, and this analysis provides a foundation on which future management guidelines can be established. Such guidelines have the potential to improve efficiency in the diagnoses and treatments of these fractures. Moreover, standardization of practices regarding the management of ITPFs should reduce costs associated with unnecessary imaging and/or orthotics. Four articles comprised of 398 patients with 819 ITPFs were evaluated, which highlights the dearth of literature available on the subject and the sparse evidence from which current management has evolved.

Presentation

Akinpelu et al.,[10] in a single-institution series, reported that the percentage of male ITPFs was roughly equal to the percentage of men with general spinal injury. Therefore, it is possible that the mean male preponderance we reported was attributable to risk factors associated with spinal injury, rather than male-specific anatomy of the transverse process. Sexual dimorphism in vertebral anatomy does exist, but no studies have described differences between transverse processes in men and women.

Schotanus et al.[11] reported that adult subaxial cervical spine ITPFs are more often single level (90%) rather than multilevel (10%). In contrast, Homnick et al.[3] reported that adult thoracolumbar spine ITPFs are more often multilevel (46%) rather than single level (44%) The latter is consistent with the literature, which reports lumbar ITPFs to be more commonly multilevel.[18,19] Akinpelu et al.[10] also reported that pediatric thoracolumbar ITPFs were more commonly single level (57%) rather than multilevel (43%). Regardless, extent of involvement had no effect on management or outcome.

Mechanism

ITPFs are most commonly caused by high-energy blunt trauma, such as MVA or collisions during extreme sport.[20-22] TPFs of the lumbar spine are the most common lumbar spine injury after blunt trauma, comprising up to 48% of such injuries.[20] MVAs were the most common cause of ITPFs, followed by falls. Less common etiologies included assault, penetrating injury, bicycle accident, crush injury, and sports injury.[3,10,11] The overall trend was similar in both adult and pediatric studies, but ITPFs caused by MVAs were significantly more common in children than adults. Conversely, ITPFs secondary to falls were significantly more common in adults. The authors attribute the latter finding to the inclusion of elderly patients (in adult series), who are prone to falls and subsequent injuries related to degenerative and osteoporotic changes of the spines.

Associated Injuries

No neurologic deficits were reported among the patients reviewed.[5,10] However, associated pain and system injuries were common.[5,10] Cervical isolated and associated TPFs have been correlated with brachial plexopathy and vertebral artery dissection or occlusion.[6,23-25] The reported incidence of asymptomatic vertebral artery injury after traumatic cervical TPF is 8.3%–25%.[26,27] TPFs that extend into the cervical (C1-6) transverse foramina are more likely to damage the vertebral artery, with incidences reported as high as 63%.[6,24,28]

The literature on brachial plexopathy and vertebral artery injury in the setting of TPFs included both isolated and associated TPFs. Schotanus et al.[11] examined cervical ITPFs and reported no brachial plexopathy or vertebral artery injuries. Woodring et al.[6] suggested that routine angiography for all cervical TPFs may not be cost-effective, but should still be used for fractures involving cervical transverse foramina and in patients presenting with signs and symptoms of a vertebral-basilar artery stroke.

Thoracolumbar TPFs are associated with abdominal injuries, most commonly lacerations of the liver, kidney, or spleen; bladder rupture; ureter transection; colic artery avulsion; and adrenal gland hemorrhage.[5,18,19] Lumbar fractures at L4 have been found to be a risk factor for abdominal injury, whereas L5 TPFs have been associated with fractures and instability of the pelvis.[29-31] Pediatric thoracic ITPFs were reported to have up to 70% correlation with head or chest injuries and 20% correlation with abdominal injuries.[10] Pediatric lumbar ITPFs have up to 45% correlation with abdominal injuries, 41% correlation with chest injuries, and 30% correlation with head injuries.[10] The higher than expected percentage of associated injuries is striking and may compel some to be more thorough when screening patients presenting with ITPFs. Specifically, ITPFs should heighten suspicion for brachial plexus, vertebral artery, and solid organ injuries, particularly in the setting of high-velocity trauma.

Management

All patients were treated conservatively without evidence of instability or deformity on serial imaging at mean follow-up of 20.5 months. The management of these fractures is not an area of debate, and there is minimal uncertainty regarding the conservative measures used in the treatment of such patients. However, to our knowledge, the literature (although limited) has yet to be comprehensively reviewed to determine whether clinical practice reflects the consensus reached.

No treatment and pain management were common among the ITPF cases reviewed.[3,5,10,11] The former approach was most frequent (80%; range, 73%–100%) (Table 1). Two studies[5,11] reported no treatment in any of their patients; Schotanus et al.[11] recommended unrestricted movement for patients with subaxial cervical ITPFs. Pain control and muscle relaxants were also commonly prescribed.[5,10]

Cervical collars, braces, and corsets were primarily used for patient comfort and not intended to stabilize the spine.[3] In fact, collars may also compress the jugular veins, reducing venous return and increasing intracranial pressure, which has the potential to cause additional neurologic morbidity.[11,32-35] Furthermore, halo vests can negatively influence recovery by affecting pulmonary function.

Currently, there are no prospective studies that have evaluated whether these devices improve healing of ITPFs and/or prevent worsening of associated injuries. Given the expense, discomfort, and lack of indications for bracing and orthotic devices in ITPFs, we caution against their use beyond the initial trauma screen, and particularly, after failure to establish radiologic evidence of spinal instability.[3]

Outcomes

Long-term outcomes for patients with ITPFs are scarce.[10,11] Akinpelu et al.[10] reported a mean clinical follow-up of 19 months for 84% of patients, with radiologic follow-up in only 26%. The authors of that study reported 100% of patients to be neurologically intact and unchanged from initial presentation. Although, a few patients reported residual pain at the first follow-up visit. Schotanus et al.[11] reported clinical and radiologic follow-up of 27.6 months in 67% of their patients. The authors of the second study reported mean cervical range of motion in all planes and mean Neck Disability Index scores to be normal. In both studies, there were no radiologic evidence of spinal instability or deformity and all ITPFs were managed conservatively. Braces or orthotics, when used, were strictly for comfort. ITPFs have not caused spinal column instability in the current published literature. Nevertheless, it is the authors' belief that screening should take place for associated injuries.

In a recent study, Boulter et al.[9] performed a retrospective review of 306 patients who presented with ITPFs and reported short- and long-term outcomes. In those patients, 97.7% of ITPFs and 100% of ITPFs without associated injuries did not require orthotics. At more than 6-months follow-up, all patients had achieved full ambulatory statuses, and only 1.1% reported persistent ITPF-related back pain. No patient had undergone surgical management for his/her ITPF. Thus, the authors concluded that spine service consultation was not required for patients with ITPFs. The results of the current study support that conclusion.

Future Studies

At our institution, a large retrospective review of patients with ITPFs is being performed to determine if a visualized TPF is truly isolated or not. That is, to identify red flags or scenarios where the diagnosis of ITPF is likely to be erroneous. The literature suggests that several risk factors exist for associated pain and system injuries in the context of spine trauma. The aim of that study will be to identify risk factors that predispose individuals to multilevel or non-isolated TPFs. The presumed clinical value of those findings will be to improve diagnostic accuracy, reduce health care costs associated with repeat scans and admissions upon the clinical manifestation of missed fractures and injuries, and limit morbidity related to undue utilization of orthotics.

Study Limitations

Limitations of this study are inherent to its retrospective nature. Despite a relatively large sample size, data on presentation, mechanism, follow-up interval, and outcomes were often deficient. Four articles were selected describing 398 patients with 819 ITPFs, but outcomes were only reported in 2 articles, and this severely limited our quantitative analysis. Moreover, we only identified 1 pediatric study, which limits the interpretability of our results in that population.

CONCLUSIONS

ITPFs are benign spine injuries. Patients often present with pain but are otherwise neurologically intact. MVAs and falls are common causes of ITPFs and are perhaps related to observed male and adult preponderances, respectively. Clinicians should maintain high indices of suspicion for ITPF-associated injuries, especially in the setting of high-velocity mechanisms. Routine angiography should be used for fractures extending into the cervical transverse foramen and in patients presenting with signs and symptoms of a vertebral-basilar artery stroke. Management is nonsurgical and includes early mobilization, pain medication, and muscle relaxants. Orthotics or bracing may hinder recovery, and we recommend against their use in ITPFs without radiologic evidence of instability.

The evidence for no-consult and nonoperative management is mounting. This study provides quantitative support for current practices, but will be unlikely to significantly alter management. Nevertheless, the results codify the experiences of multiple institutions and provide data to support long-standing practices, which are based on limited evidence. Importantly, the study highlights an existing need to determine if a visualized ITPF is truly isolated and to report on long-term outcomes (e.g., functional status) of patients with ITPFs and associated injuries.

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