

Presumptive Long Rod Technique (PLRT) for Revision Extension Instrumented Spine Surgery: A Technical Note

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Abstract

Background: Revision spine surgery needing extension of fixation either require complete exposure of previously operated levels for rod exchange or can be managed by linking the new surgical construct (NSC) to primary surgical construct (PSC) with dominos. Presumptive long rod technique (PLRT) provides additional length of rod for domino placement.

Case report: 80-year male on conservative management developed acute cauda equina syndrome retention due to pre-existing multilevel lumbar stenosis and acute big sequestered disc prolapse at L12. Emergent surgical intervention in form of L1 to L4 pedicle screw fixation with postero-lateral bone grafting and fragmentectomy was done. Peri-operative period was uneventful. He was started on Teriperatide 20mcg daily with progressive mobilization and physiotherapy. At 4 months of follow-up, he developed L1 osteoporotic fracture with proximal junctional kyphosis (PJK). Patient underwent T12-L1 interbody fusion with extension of fixation to T10 which required complete opening up of previous incision as it was an Indian implant set. A domino of larger foot print couldn't be accommodated in the space available between L1- L2 screws. Owing to severe osteoporosis and degenerative changes at proximal levels, presumptive oversized rods were inserted with extra lengths of the rods left at proximal ends. This technique is labelled PLRT (presumptive long rod technique) at our institute. At 6 months of follow up, patient developed T10 osteoporotic fracture with PJK and patient was planned for extension of fixation upto T4. Since the extra lengths of rods were available at proximal ends, only the planned operative levels were exposed and it was connected to previous construct using the larger footprint domino. Patient improved clinically and was ambulatory. The patient expired at 18 months due to cardio-respiratory arrest unrelated to the spinal events.

Conclusion: Additional rod lengths intentionally left at adjacent levels during primary surgery where there is anticipation of PJK and adjacent segment disease (ASD) can be a boon when there is need for extension of fixation. These extra lengths of rod can be used to place dominos and connect PSC to NSC without the need for exposure of PSC levels for rod exchange, preventing complications especially in setups with economic constraints.

Keywords: Complex, Adult Spinal Deformity, Adjacent Segment, Junctional Kyphosis, Osteoporosis, Revision, Surgery, multi-rod.

Introduction

Spinal instrumentation, especially with three column fixations like pedicle screws and rod construct has been revolutionary in treating most of the spine deformities, degenerative pathologies, instability, infection and tumours [1]. Increased longevity along with exponential number of spinal fusions come along with increased rates of complications like, but not limited to Adjacent segment disease (ASD), Proximal junctional kyphosis (PJK), spinal canal stenosis, vertebral fractures, pseudoarthrosis and instrumentation failure [1, 2].



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ASD is multifactorial and exact etiology cannot be pinpointed, however has been hypothesised, but not limited to because of fractures (facet and/or vertebral), accelerated degenerative disc disease and increased stress at stiff bone implant interface [3].

There are two principal treatment options when extension of the posterior fixation systems is unavoidable. The first option is re-exposing the primary construct levels along with the levels needed to be instrumented and then exchanging the old rods with new long rods to accommodate new instrumented levels with primary fused levels. The alternate option is to expose only the levels needed to be instrumented and then connect the new surgical construct (NSC) to primary screw construct (PSC) using specific dominos/rod to rod connectors, sparing the exposure of primary construct levels in entirety [1]. This method has the advantage of involving a smaller incision with the associated reduced blood loss and operation time. Both techniques afford comparable stability of the entire construct [1]. A great variety of western pedicle screw systems are currently available for posterior lumbar fixation. The manufacturers of these systems offer surgeons diverse options for extending an existing primary screw construct (PSC). Depending on the vertical alignment of the pedicle screws, the surgeon may use either end-to-end or side-to-side Domino to extend the rod system [17].

But, these Domino like its pedicle screw systems are costly and non-affordable in its modular availability in our Indian subcontinent. Most of the systems available here are not open systems and need a certain length of the rod available to thread the Domino. If rod length is not available, then disengagement of the junctional rod to screw is needed to couple the connector to the existing construct. We describe here a simple technique of presumptive long rod Technique (PLRT) in cases of possible ASD to allow usage of it if a need arise in future.

Case report

80-year-old male presented to our spine clinic with complaints of low back ache and left lower limb radiculopathy. His radiculopathy was severe, limiting his walking distance to less than 500 meters with no urinary or bowel symptoms. On radiological imaging patient was diagnosed to be a case of L1-L4 stenosis with L3-L4 Degenerative listhesis with degenerative scoliosis. He was initially given conservative trial in the form of pain medications, life style modification, selective nerve root block. He responded for few good months while on conservative trial. Then patient developed acute cauda equina syndrome (retention) with bilateral radiculopathy and was planned for emergent surgical intervention (Figure 1). Patient underwent L1 to L4 pedicle screw fixation with postero-lateral bone grafting and L1-L3 laminectomy. L1-L2 disc prolapse fragmentectomy was done

(Figure 2). Post-operative period was uneventful and he was mobilized with lumbosacral corset and support regular catheter care and bowel training guidance was carried. He was started on Teriparatide 20 mcg daily for being osteoporotic. At 2 months follow up, patient improved significantly in patient reported outcome measures (PROM) with compensated urinary and bowel habits of some straining and managing basic ADL (activities of daily living). At 4 months of follow-up, patient developed sudden increase in severe back pain at operative site with difficulty in walking. On repeat radiological imaging, L1 wedging with PJK and ASD was diagnosed (Figure 2). Patient was operated for T12-L1 interbody fusion with extension of fixation to T10 (Figure 3). Compatible Domino were not available in the used implant system of screws. The available Domino, though an open system, had bigger foot print and was not accommodable in the length of rod available between L1 and L2 screws. Revision necessitated opening of the entire old construct rod for the new reconstruction in view of the fact that the patient was not affording for western modular system of revision surgery. Owing to osteoporosis and degenerative changes at proximal levels, intentional oversized rods were inserted with extra lengths of the rods left at proximal ends. This technique is labelled PLRT (Presumptive long rod technique) at our institute (Figure 3). Post-operatively he again gained independent mobility with progressive improving patient reported outcome measures (PROM). At 6 months of follow up, patient again came with severe pain and imaging studies revealed T10 osteoporotic fracture with PJK (Figure 3) and patient was operated for extension of fixation upto T4 (Figure 4). Since, the extra lengths of rods were available at proximal ends (PLRT) and there was no additional need for rod exchange this time. Only the planned operative levels were exposed. Patient underwent extension of fixation (New screw construct: NSC) using a separated rod and it was connected to primary screw construct (PSC) using larger footprint Domino. Patient improved in all PROM and was ambulatory and doing all basic activities (Figure 4). The patient expired at 18 months due to cardio-respiratory arrest unrelated to the spinal events.

Discussion

Spinal instrumentation has been mainstay in management of spinal pathologies and deformities of increasing complexities [4]. With increase in spinal instrumentation, there is increase in revision rates as high as 37% reported for lumbar spine surgeries [5]. Major spinal instrumentation is fraught with complications like infection, pseudoarthrosis, junctional kyphosis, adjacent segment disease [6, 7]. The multifactorial risk factors for ASD/PJK after lumbar fusion surgery are age, genetic factors, high body mass index, pre-existing adjacent segment degeneration, laminectomy at the adjacent level of fusion, excessive distraction of the fusion level, insufficient

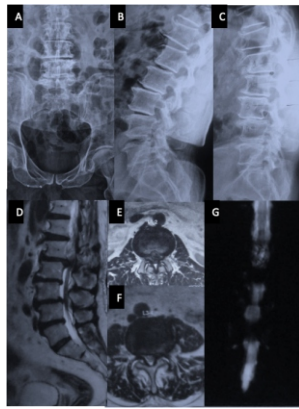


Figure 1: Figure (A, B, C) Radiographs showing degenerated lumbar spine with L3/4 anterolisthesis, L2/3 and L1/2 retrolisthesis, multiple Knupton's signs and osteoporosis. (D, E, F) MRI with L1/2 sequestered big central disc prolapse, multilevel and L3/4 major facet arthrosis and stenosis. (G) MR myelogram showing complete myelo-block at L1/2 and L3/4 level.

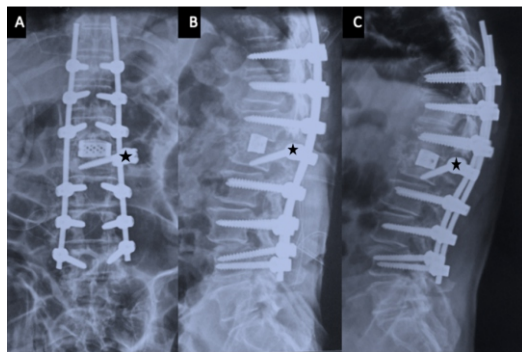


Figure 3: (A, B) Radiographs after 2nd surgery with anterior bonegraft, cage interbody reconstruction, correction of deformity and rod exchange. Opening up of the index surgical region was needed. The new rod was intentionally kept longer at proximal junction (PLRT-presumptive long rod technique). Note the Offset screw (*) with extrapedicular trajectory connected with offset connector. (C) 5 months post-operative follow-up, patient developed osteoporotic fracture in T10, the upper instrumented vertebra.

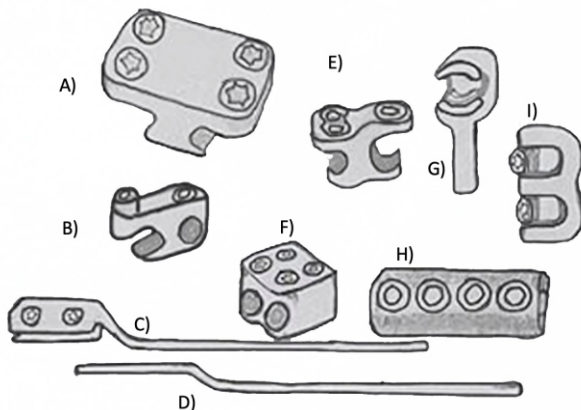


Figure 5: Representative illustrations of available Dominos A) Parallel Domino, 4 set screws, both open threading (side/side loading). B) Parallel Domino two set screws, open and closed threading (front/side loading). C) Revision integrated Domino rod with inline Domino with two set screw. D) Revision rod with pre-bend. E) Parallel Domino, three set screws, both open threading (side/side loading) with modularity of rod size. F) Parallel Domino, 4 set screws, both closed threading (front/front loading). G) Offset connector, to connect a different trajectory screw to main construct rod. H) Inline Domino, four set screws, both closed threading with no modularity of rod size. I) Parallel Domino two set screws, both open threading with no modularity for rod size. [14, 15]

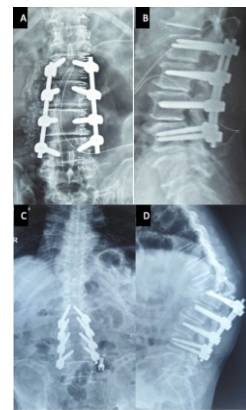


Figure 2: (A, B) 1st post-operative radiograph showing reasonable lordosis achieved with stabilization from L1 to L5 with postero-lateral bone grafting. (C, D) 5 months follow up with adjacent segment disease with proximal junctional kyphosis and toppling.

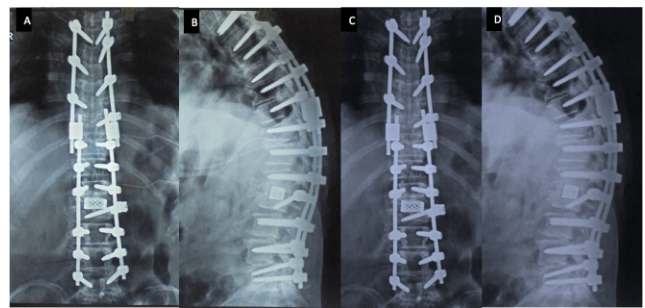


Figure 4: (A, B) 3rd surgery post-operative radiograph with extension of screw construct on the PLRT rod (PLRT-presumptive elongated rod technique). Previous surgical area was not opened. (C, D) 13 months follow-up radiograph with stable reconstruct and favourable patient reported outcome.

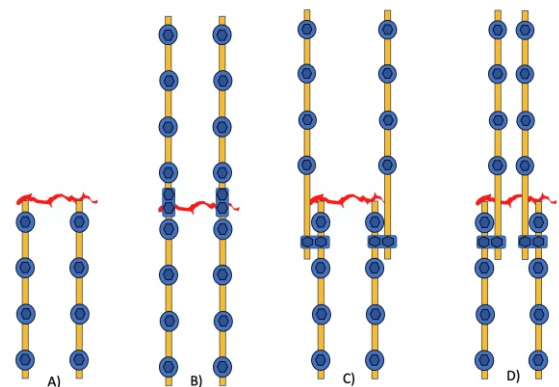


Figure 6: A) Illustration showing primary spine construct (PSC) with adjacent segment disease (red crack) needing an extended new spine construct (NSC). B) PSC connected with 'inline' Dominos to the extended NSC. C) PSC connected with 'parallel' Domino's with extended NSC. The outside construct needs extra-pedicular screw trajectory. D) PSC connected with 'parallel' Domino's with extended NSC. The inside construct needs straighter pedicular screw trajectory.

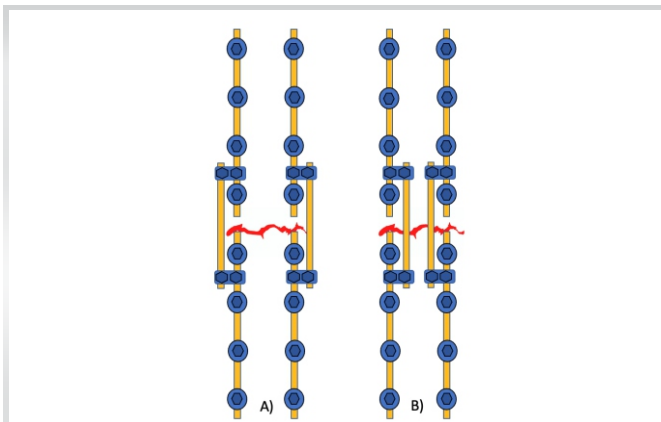


Figure 7: A, B) Illustration showing primary spine construct connected with outside or inside 'Intercalary rods' with two Domino's each side with extended new spine construct. Here surgeon can use same technique of previous pedicle screw trajectory.

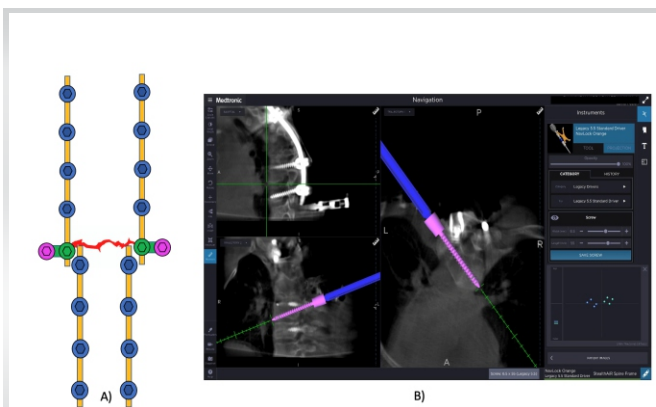


Figure 9: Illustration showing 'Offset connector' connecting non-pedicular direct body trajectory screws put in the primary spinal construct connecting to the new spine construct. The outside construct needs extra-pedicular screw trajectory. Observe that the rods are not connected. B) Similar direct body trajectory screws put in a non-index case, with Medtronic O Arm Navigation. Pre-existing retained conventional pedicle screw is visible.

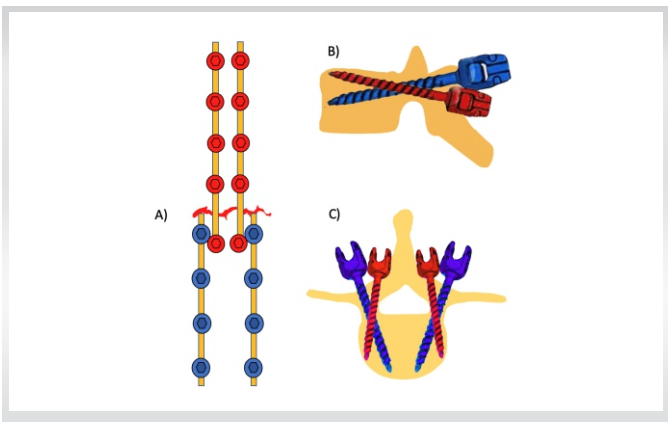


Figure 10: A, B) Illustration showing primary spine construct connected with 'revision integrated domino rods' with extended new spine construct. C, D) Primary spine construct connected with pre-bend revision rods and separate domino to extended new spine construct. In all these constructs, surgeon can use same technique of previous pedicle screw trajectory.

lumbar lordosis, multilevel fixation, floating fusion (multilevel fixation with lower end-vertebra of L5, coronal wedging of L5-S1 disc, increased pelvic tilt, osteoporosis and excessive soft tissue disruption adjacent to surgical level [8]. ASD as observed by us presents as a disc degeneration, stenosis, facet instability, trans-discal instability with facet fracture or UIV (upper instrumented vertebrae) vertebral body fracture or adjacent vertebral body fracture. This has been reported as well [3]. The incidence of PJK varied from 20% to 39% in posterior instrumented fusions [9].

The treatment though initially conservative may convert to operative if painful, especially in presence of a neurological affection. There have been many preventive strategies described in the literature namely use of sublaminar wires [10], transverse process (TP) hooks [11] and Graf ligamentoplasty procedure [12]. Sublaminar wires maintain sagittal balance and need minimal dissection near adjacent levels for insertion and stabilization. Whereas, later three achieve dual goals of maintaining sagittal balance and decrease

the stress of adjacent segments seen with rigid fixations [10-13]. Thus, promoting less stiffer transition zone. However, it is not possible to avoid ASD or PJK completely. Various techniques have been adopted in revision extension surgery (RES) where additional proximal or distal NSC: need to be wed into the PSC. Multiple type of dominos (rod to rod connectors) can be used to connect two rods (Figure 5). Inline (open/closed) or parallel (open/closed) dominos are available. These dominos can be with 2, 3 or 4-set screws, side/front/top loading and offer modularity of offset and rod size also [14, 15]. Better yield-fatigue strength has been reported with closed domino relative to open domino connectors [16]. Stiffness of parallel and inline connectors are comparable in terms of range of motion and neutral zone [1]. Closed inline or parallel dominos are difficult to thread to a rod if there is any small bend which are unavoidably needed many a times. Multiple ways to connect NSC to PSC can be categorised in following four ways: (i) PSC and NSC can be connected to each other by intercalary rods (inside or outside)

or one inline domino (Figure 6, 7). Intercalary rods if used needs two dominos [17]. (ii) Using new anchor points like additional screws of cortical bone trajectory within the PSC and then connecting it to NSC with a rod (Figure 8) [17]. Offset connectors have been extensively used to connect and extend to lumbopelvic fixations. Offset screws can also be used at the base of the NSC (Figure 9) [18]. Observe that in these both constructs the rods are not connected. (iii) Integrated domino revision rods can be used negating the need for separate domino, reducing the stress at the domino rod interface (Figure 10) [19]. (iv) Use of sublaminar wires, tapes, and hooks to create a hybrid construct connected to PSC is also possible. It's known that the posterior elements especially lamina is comparatively stronger in osteoporosis [20].

The comprehensive types for multirod constructs across three column osteotomies as suggested by El dafrawy et al, and can be integrated to increase the strength of construct. Multiple ways of increasing stiffness at high stress regions can also be incorporated with the current PLRT technique to increase strength of construct [21, 22].

RES when indicated, requires exposure of the primary construct levels for exchange of implants leading to increased length of surgical incision, operative time, blood loss and peri-operative morbidity [23]. To circumvent these complications, we introduce the technique of PLRT, wherein additional rod length is intentionally left at adjacent level during primary surgery when there is anticipation of PJK or ASD. This is suggested when Indian implants without the full armory of revision surgery is used in cost constrained patients. With our PLRT technique we have a ready rod length to connect a domino for extension. A parallel or in line domino, that too 4 set screw types can be used making it easier and stiffer. This allows usage of both open and closed system of dominos. Traditionally, to place another inline domino, opening of the proximal screws are needed. Our technique avoids opening of the previous construct thus indirectly reducing the surgical injury, blood loss and surgical time. Moreover, only one domino is needed on either side as against the two mentioned for intercalary rods. Another advantage specially in thoracic spine is that, the inter screw distance being smaller, does not allow placing of a 4-set screw type domino [19]. This may also theoretically add to cost, bulkiness and even MRI artefacts. There is a technical problem with this PLRT technique that the new screws of the NSC need to be in a different trajectory than the PSC, either more converging or straight. This will necessitate more surgical know-how than the comforting technique of pedicle screw insertion of the operating surgeon. Though, this can be circumvented by navigation guided screw placement with its own logistical pitfalls. But, the same issue is also noted in previous suggested few techniques (Figure 6 C,D;

Figure 8; Figure 9). Also, intercalary system of extension allows more space laterally in inter-facet area for bone graft bed as the rod is either outside or inside and not exactly overlying the inter-facet area. Though, this is negated if interbody fusion is carried out.

Limitations

The main limitation of this report is its retrospective way of reporting as a case-based technique instead of a case series. The series of patients managed with this construct at our centre now includes 31 patients with varying pathologies. This was used when cost constrain was very high. Out of these, 8 patients had been revised with current PLRT technique who developed ASD. It is not currently reported as a series because bias would be unavoidable if all different pathologies are clubbed to make a series. Though, better western system is available which would negate the utility of PLRT but it's worth an out of box thought option in cost constrained or implant constrained set up. Moreover, the Indian companies are not providing all types of modular options of dominos. We, also accept that this study was not set up to compare stiffness, costs, fusion or complication rates between different other existing techniques. However, it was reasonable to assume that the overall cost would be lower since being Indian origin system and the use of number of dominos was always only two, and it could be translated to a reduced cost. Bending stiffness and torsional rigidity needs to be studied to establish it's more universally. The PROM and deformity alignment standard measurements of radiograph were not discussed in this case because, the purpose was to report only the technique. This technique is a novice technique to suit to the needs of our establishment where revision surgery is also on rise. More prolific use in varied pathology and regions of the spine, by multiple centres is recommended to identify its true potential. It's a known fact that controlling the expenditure of the exchequer is a target in most of the developed world as well [24].

Conclusion

PLRT offers a simple effective way of revision implant extension surgery, when cost or availability is a primary constrain.

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Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his/her consent for his/her images and other clinical information to be reported in the Journal. The patient understands that his/her name and initials will not be published, and due efforts will be made to conceal his/her identity, but anonymity cannot be guaranteed.

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