Current concepts: approach to spondylolysis

Robert N Dunn*

Department of Orthopaedic Surgery, University of Cape Town, Cape Town, South Africa

**Corresponding author: robert.dunn@uct.ac.za*

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Abstract

Lumbar spondylolysis is an acquired defect of the pars interarticular process ('isthmus') due to the human species' erect posture. Anatomical and load factors play a role. With lumbar extension, the superior vertebra's inferior articular process drives down dorsally on the inferior pars, causing a ventral tensile stress, bone oedema, fracture, and ultimately nonunion in some. The population incidence is around 6%, where most are inconsequential as they are asymptomatic and have a favourable natural history.

In the physically highly active group, especially athletes, back and radicular pain is more common, leading to a three to four times higher incidence of lysis in this group.

Although X-rays are typically the first imaging modality used, computed tomography (CT) is far more sensitive and, with staging, more predictive of fusion with comparable radiation dose. Magnetic resonance imaging (MRI) allows identification of bone oedema, a precursor of fracture, and assessment of the disc status. This has replaced previously used isotope bone scans and single-photon emission computed tomography (SPECT).

Management involves cessation of physical activity and bracing to block extension for three to six months, with around 90% resolution of symptoms. Union rate is negatively related to bilaterality and terminal stage (nonunion), but not necessarily correlated to symptom/functional status.

Surgical intervention in those that fail nonoperative care includes pars repair or fusion, with a high fusion and return to activity rate.

The young athlete poses a particular challenge due to return to play pressure, but still does well with nonoperative care and subsequent activity modification. Counselling of the family and sports staff is extremely important when planning treatment in this high-demand group.

Level of evidence: Level 5

Keywords: lumbar spondylolysis, diagnosis, management, athletes

Spondylolysis is a defect in the pars interarticularis, also known as the isthmus, the bridge between the superior and inferior articular processes. It may be uni- or bilateral, with the latter disconnecting the anterior and posterior columns of the vertebral unit, increasing stresses on the disc with accelerated degeneration and possible anterior slip, viz. spondylolisthesis. Although not necessarily symptomatic, when it is, it may present with axial and radicular pain in the child or young adult.

The condition is acquired rather than congenital, with an incidence of 4.4% in the North American population at the age of 6 years, increasing to 6% by adulthood, with a static incidence thereafter.[1] The incidence is higher in some select groups such as the Inuit population, where a 54% incidence was identified in a small series of 46 spines.[2]

The condition appears to be the price of the erect posture as it has not been identified in nonambulatory patients. Rosenberg studied 143 spines in patients that never walked, mostly due to severe cerebral palsy, and did not identify a single case of lysis.[3]

Spinal hyperextension is thought to be the cause of the lysis, with the inferior articular process of the vertebra above impinging on the pars below and causing a stress fracture. Terai et al. demonstrated this caudal-ventral stress fracture with finite element analysis and correlating with CT and MRI scans of spondylolytic adolescents. This occurs as the tensile forces are higher ventrally due to the repetitive load and dorsal impingement force.[4]

The human skeleton differs from all other mammals by having an increasing lumbar interpedicular distance from cephalad to caudal. This allows lumbar lordosis and consequently efficient erect ambulation as the superoinferiorly contiguous facets can imbricate. Ward compared skeletons with bilateral lysis and those without, and confirmed that spondylolytic patients had reduced pyramidal increase in the interpedicular distance and thus had an anatomical vulnerability.[5]

Sports activity increases the incidence of lysis significantly. Soler studied a Spanish sporting population and reported a 10–26% lysis prevalence in various sports, increasing from weightlifting, volleyball, swimming, rowing, trampoline, gymnastics to the throwing (26%) athletes.[6]

The natural history of spondylolysis is favourable. Beutler followed up the 30 juvenile spondylolytics some 45 years after they had been identified in their earlier study. Of these 30 patients, 22 had bilateral pars defects and eight unilateral defects, mostly at L5. Three patients had died during the study period. Of the eight unilateral spondylolytic patients, three had spontaneous healing. None had progressed to a listhesis. Only two reported moderate back pain. Of the bilateral spondylolytic patients, 18/22 had slipped with minimal progression. One unilateral and one bilateral had undergone discectomy surgery and one bilateral a fusion. The Short Form 36 Health Survey Questionnaire (SF-36) data was the same as the age-adjusted population.[7]

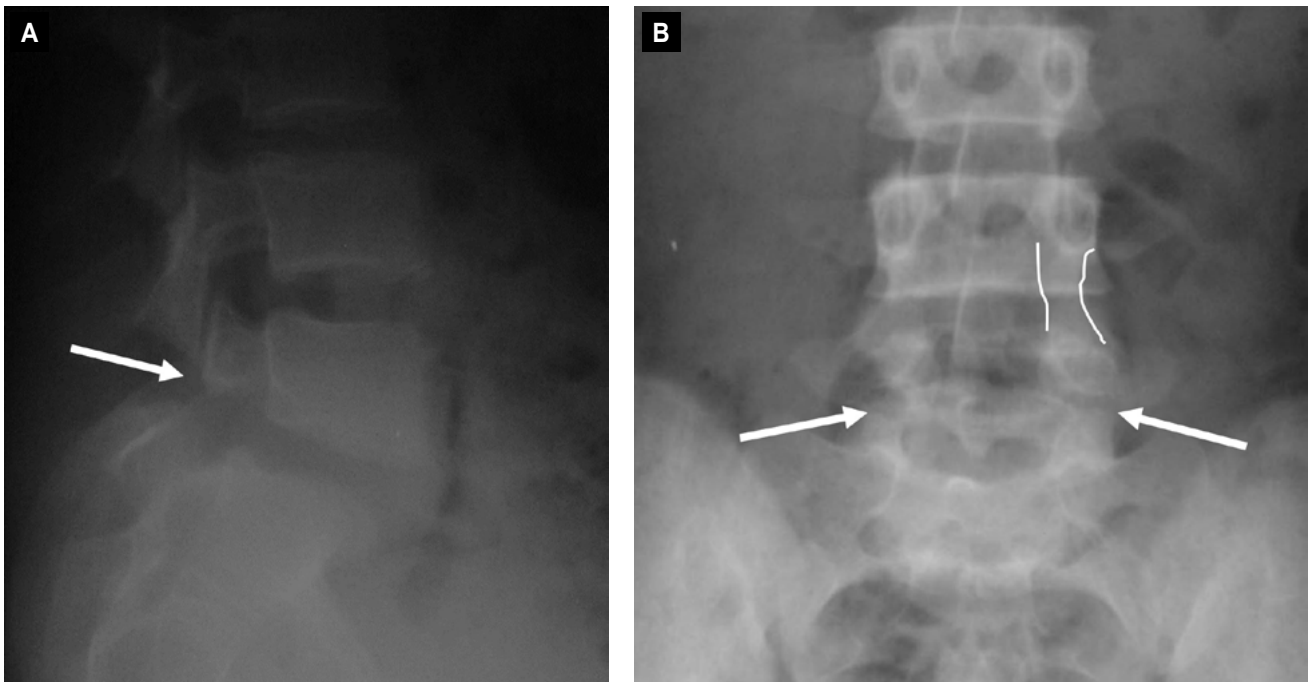

Figure 1a (left). Lateral X-ray confirming sclerotic defect just inferior to the pedicle

Figure 1b (right). AP X-ray indicating the intact L4 pars between the white lines, whereas the L5 level suggests a defect as indicated by the arrows

Although most spondylolytic patients remain asymptomatic, or at least at the same symptom level as the general population, some do present for medical care.

Clinical scenario

In the author's experience, there are two main clinical scenarios. The first is the adolescent with some back and/or radicular pain, usually associated with sporting activity, and the other the young adult with a secondary degenerate disc, listhesis and predominantly radicular pain.

The second, not the focus of this paper, is usually a straightforward decision-making process. When the pain is functionally debilitating, there is usually disc degeneration with height loss and foraminal stenosis. This can be successfully managed with decompression of the foramina by disc height restoration with an interbody cage and fusion.[8]

The adolescent with lumbar lysis is far more of a challenge. The child generally presents with some back and/or buttock or leg pain. The leg pain is often initially attributed to soft tissue injury such as hamstring injury, as it can initially be vague in nature. There is usually a history of sport, frequently excessive, and a reluctance to stop. This is often further complicated by family and sports staff expectation.

On examination, the child may appear completely normal. Usually there are tension signs with a reduced straight leg raise. This is often (incorrectly) attributed to 'tight hamstrings' rather than radicular irritation. When more severe, there may be altered sensation. As it is usually the L5 level involved, which irritates the respective L5 root, there may be reduced sensation in the anterolateral thigh, lateral calf, dorsum foot, hallux and ball. Tension signs may be present. Motor weakness is infrequently identified.

Imaging

The lysis, particularly if unilateral, can be difficult to visualise on standard lumbar imaging. By comparing adjacent pars, lysis may be visible, as in *Figure 1a and b*.

Historically, oblique lumbar X-rays were requested where the pars (often referred to as the neck of the Scotty dog) is better visualised (*Figure 2*). Today CT is more accessible and helpful in this regard. Fadell confirmed the far higher interobserver reliability of CT at 0.88 compared to 0.24–0.4 for X-rays with up to four views. With their limited Z-axis CT protocol, they could achieve lower radiation exposure than the multiple X-rays, and concluded this would improve the use of iterative reconstruction algorithms in the newer CT scanners.[9] *(Figure 3)*

MRI is a safe and useful imaging technique as it uses non-ionising technology. It allows detection of bony oedema in the pedicle and pars. Where the pars is still intact, this confirms a 'pre-fracture' stress response. In addition, it allows the assessment of

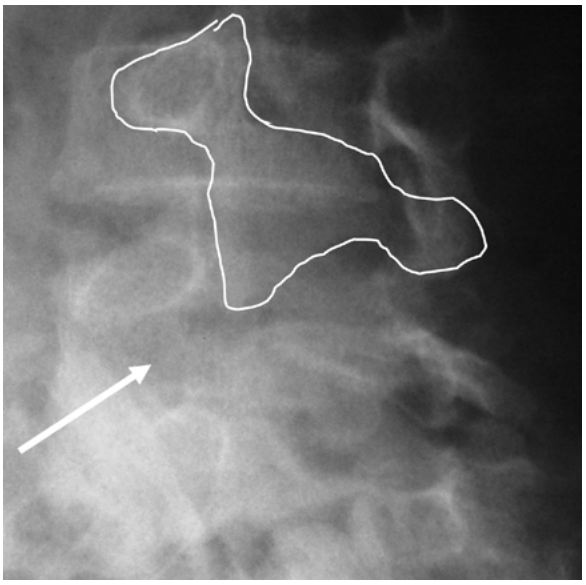

Figure 2. Oblique lumbar view demonstrating the intact 'Scotty dog' superior articular process, pedicle, pars and lamina with the absent 'neck' the level below confirming the lysis

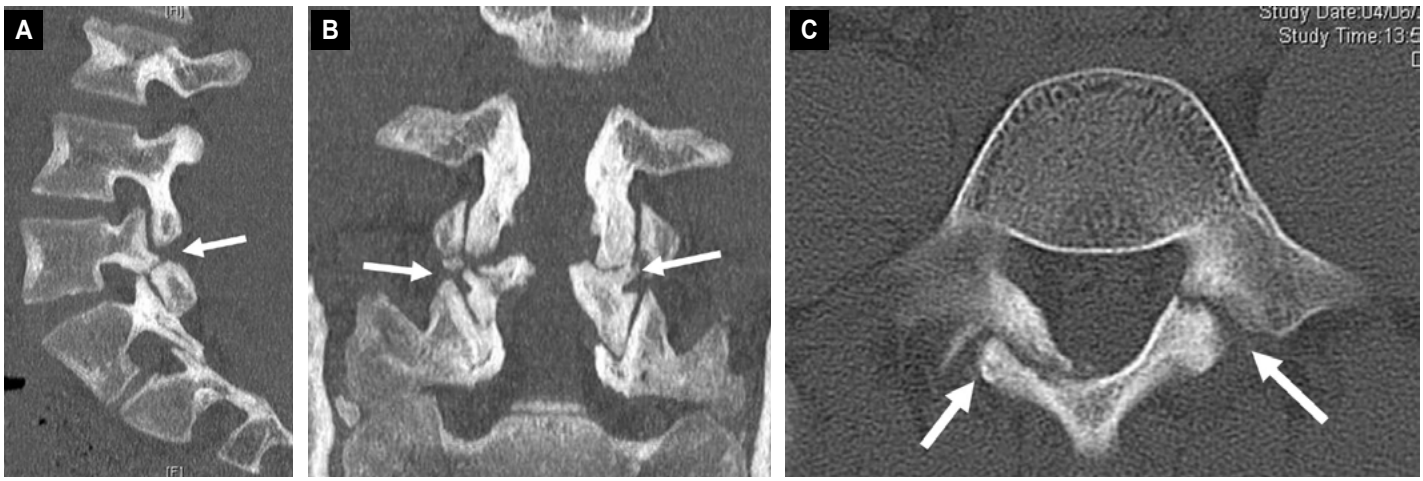

Figure 3. CT scan confirming bilateral chronic lysis on sagittal (a), coronal (b) and axial (c) views

the disc status and potential role as a pain generator. The lysis may be visualised but oedema in the pedicle is suggestive, as in *Figure 4*.[10] This oedema was correlated to the earlier CT stages of lysis and its presence suggested potential spontaneous healing.[11]

Technetium 99 isotope bone scans/SPECT (single-proton emission computer tomography) have historically been used to assess the biological activity of the lysis, where 'hot' scans (uptake of the phosphate and tracer) implied ongoing fusion potential. MRI has largely replaced this, making the additional cost and invasive nature of the nuclear scan difficult to justify.

Classification and 'healing' rates

Lytic lesions are classified by level, with L5 the most common, uni- versus bilateral, and evidence of chronicity. These impact the probability of successful nonoperative care.

Fujii reviewed 134 spondylolytic children in terms of imaging and outcome.[12] They classified the defects by stage. An early defect was defined as a pars fissure. A progressive defect was still narrow with rounded edges. If the defect was wide and sclerotic, it was deemed terminal. Despite identifying union (disappearance of the lesion) at six months on X-ray, trabeculation was only complete at 12 months on CT. They further classified the lumbar spine maturity based on the appearance of the secondary ossification centre of the cranio-anterior edge of L3 body on plain X-ray. They confirmed far higher union rates in the early stage compared to progressive and terminal. L4 defects had higher union rates than L5. Union was higher in unilateral or bilateral, where the contralateral defect was early.

Sakai et al. added a 'very early stage' where there was an MRI stress reaction with no CT fracture line.[13] They reported on 63 patients managed conservatively. They confirmed the high union rate in all but the terminal group, where none of 14 fractures healed. They further reported a 26% recurrence of back pain with resumption of activities. These patients all had MRI-demonstrated oedema but eventually fused.

Nonoperative management

Due to the favourable natural history, most patients can be managed nonoperatively, with an expectation of lysis bony healing in the nonterminal staged defects. Even in those that are unlikely to heal, e.g. L5 bilateral terminal stages, the symptoms may well settle. As Beutler's 45-year review confirmed few progress to significant listhesis or surgery, this may be enough.[7]

Although the specifics of nonoperative care may vary, the principles are immediate cessation of sporting activity and

Figure 4. T2 MRI sagittal sequence with pedicle hyperintensity confirming oedema and visible lysis

avoidance of lumbar extension. This is often augmented with a brace, varying from an extension-blocking soft lumbar corset to a thoracic lumbar sacral orthosis (TLSO) hard brace. In the author's opinion, a TLSO risks increasing lumbosacral motion due to the induced long lever arm. To effectively stop lumbosacral motion, a thigh extension is required but seldom tolerated. Therefore, the author favours a lumbosacral brace extending as low as possible to capture the iliac blades and pelvis but not extend to the thigh.

Generally, this brace-rest regimen is for a minimum of three months.

Trunk muscle-strengthening exercises are proposed once the pain settles. Fujii recommended those that showed signs of healing at three months on imaging should refrain from sport for an additional three months. Paradoxically, those indicating nonunion at three months, but with resolution of pain, could return to their previous exercise.[12]

Alongside this is the surgeon's very subjective assessment of what is reasonable physically activity. For the author, this is the crux of the matter as often the child is pain free with normal activities, but in pain when returning to prior sport. The decision then is whether to avoid the aggravating sporting activity or allow the pressure to drive more aggressive intervention.

One needs to interrogate the family dynamics and understand the concerns and pressures. One needs to assess whether it is the child or the parents driving the activity, and whether the activities can be modified. Exercise may be beyond the child's physical

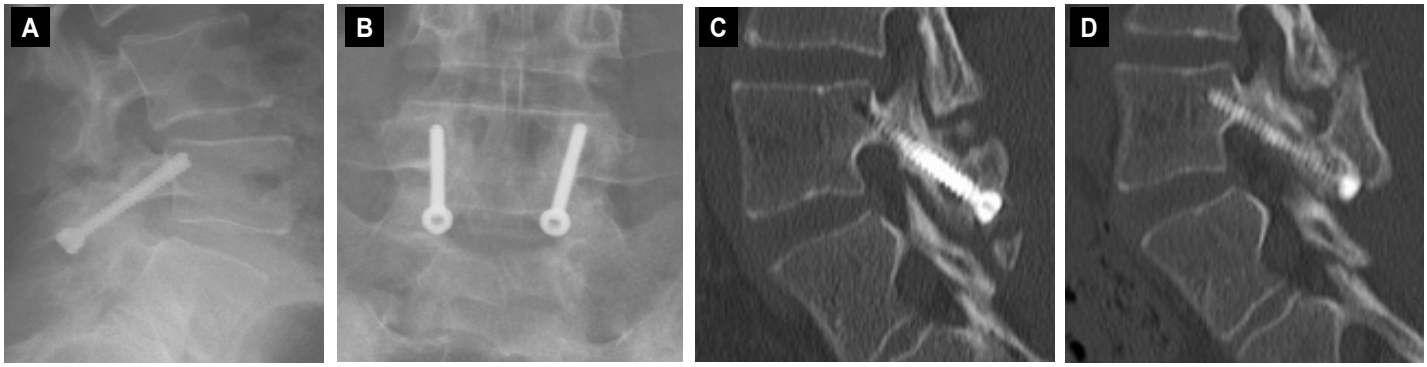

Figure 5. Author's case of Buck's intralaminar repair using 3.5 mm screws as seen on lateral (a) and AP (b) X-ray, with successful fusion on six-month CT scans (c and d)

tolerance. It is not infrequent to learn, on deeper enquiry, that the child is bowling at practice and games for more than one team, i.e. school and provincial. Restricting cricket bowling to 30 overs per week may well control the symptoms. One also needs to assess the likelihood of the child playing competitive sport in the longer term, i.e. in the professional arena, and discuss with the family whether intervention is justified if the child is only going to play school sport.

These are all very case-specific questions and answers, and require skills and time that the surgeon may not have. Yet, it is very important to explore before moving on to the next step of possible surgery. A candid discussion with the child and family is mandatory.

Operative management

A small group of spondylolytic patients will experience ongoing back and/or leg pain despite a period of conservative management, or once returning to reasonable sporting activity. Surgical intervention may be indicated. The options are fusion or pars repair.

Schlenzka reported on 48 spondylolytic and low-grade listhesis patients with 15-year follow-up who had either undergone an uninstrumented fusion or pars repair using the Scott's cerclage wire method.[14] The fusion group did better in terms of a lower Oswestry score, despite being similar between the groups at earlier follow-up. In only 43% of the repair group was the lysis conclusively healed. The L3-S1 motion was similar between the groups. MRI confirmed degenerative changes of the repaired levels' disc. There was no difference in suprajacent disc degeneration between the groups. He concluded that, despite the results of repair being satisfactory in most patients, the theoretical benefits of motion preservation and suprajacent disc protection could not be confirmed.

Although this study has a long 15-year follow-up, it still only reviews patients in their late 20s to early 30s. In the author's opinion, repair in well-selected patients should be considered.

Preferably, for pars repair, there should be no listhesis on a standing lateral X-ray, as this would suggest some disc functional compromise. However, cases with grade 1 listhesis may still be considered when the MRI confirms a normal-looking disc.

CT-guided lysis blocks have been used to assess the pain contribution, i.e. if the pain resolves, it is likely the lysis is the cause of pain, and by inference will resolve with successful lysis repair. Schlenzka is critical of this assumption due to the paucity of evidence.[14]

There are various repair options where the lysis is debrided, grafted and fixed. The Buck's fusion is the author's preference.[15] It involves debridement of the lysis, and passage of a screw from the inferior lamina edge in a cephalad and lateral direction towards the pedicle to lag and compress the defect, followed by bone grafting.

The author routinely uses cancellous posterior iliac graft and decorticates the transverse process, lateral facet and dorsal lamina to maximise fusion surface. While lagging, the gap is not fully closed if excessive sclerotic bone was removed to avoid changing the lamina 'length' too much, but rather graft interposed around the screw in the defect. Although 4.5 mm screws are generally reported in the literature, the author finds the diameter difficult due to thin lamina and defaults to 3.5 mm (*Figure 5*). Other techniques involve wiring around the transverse processes and lamina (Scott), pedicle screw with wire to tension the lamina and close the defect, and screw-hook combinations.

Fusion rates and good outcomes, at least in the early few years, are in the 85–90% range.[16-18]

A word on the athlete

The child with exceptional athletic ability and high performance adds tremendous pressure to the surgeon. The patient, family and coach want clear answers, which the surgeon of course does not always have. The herd is studied but individuals treated, making it very difficult to predict if the individual will be in the 90% successful nonoperative patient group or part of the 10% that fails and is a surgical consideration. One season may be lost with failed conservative care, followed by another with surgery. This may mean the end of the sporting career despite symptom resolution.

Athletes with back pain have a three to four higher lysis incidence than the population, and earlier investigation is therefore indicated.[6,19] Kountouris et al. make a case for the use of MRI to identify bone oedema and monitoring resolution.[20] More than half of cricket bowlers have bone oedema on the pre-season MRI, of which 73% went on to symptomatic lysis, over an average period of 96 days. Therefore, in high-risk individuals, MRI can be used to identify pre-lysis oedema, allowing reduction of exercise until resolution and then protected reloading.

Panteliadis et al. reviewed 25 publications concerning the spondylolytic athletic population in terms of outcome.[21] A total of 390 athletes with lysis were managed conservatively, mostly in a TLSO. They confirmed that 88% of the athletes had good to excellent results as defined by return to full activity, no brace requirement, and no or occasional ache with vigorous activity. Lysis union was not necessarily achieved. Return to play was at an average of 3.7 months.

An additional 174 patients had undergone surgery at a relatively older age of 22.3 years. The Buck procedure was the most common. There was more focus on union in these papers, with a range of 65–100%. Ninety per cent returned to play at an average of 7.9 months.

This makes decision-making difficult with the time pressure the athletes bring, as only 10% will fail nonoperative care, so one cannot justify operating without trial of conservative care despite the cost of time. There is no direct correlation between stage of lysis and return to play, as symptoms may settle despite ongoing nonunion of the terminal staged bilateral lysis.

In many patients, nonoperative care fails due to noncompliance in a short period, which may lead to surgical consideration. The author has experienced this with one patient agreeing to nonoperative care after full family counselling, only to go on rugby tour as the linesman – hardly resting!

In the end, the surgeon armed with this knowledge needs to adequately counsel the family and patient and then make a subjective reliability judgement. In patients with unilateral or early-stage bilateral lysis, union and symptom resolution is high with nonoperative care. Patients with significant long-standing back and leg pain with bilateral terminal stage lysis, and especially a suggestion of listhesis, are very unlikely to unite, although symptoms can improve with rest/change in activity where possible. Where not, repair is a reasonable consideration.

Summary

Lumbar pars interarticularis lysis is relatively common in the general population at 6%. In many patients it is an incidental finding that requires no further intervention due to its benign nature.

Symptoms are more frequent with sporting activity, leading to athletes presenting with back pain having a higher incidence of lysis.

The vast majority will settle with rest. Some will experience recurrence of symptoms with activity resumption, and the level of activity needs to be considered as to whether it is reasonable or not. The majority of the 10% that fail conservative care do well with surgery.

Surgery for all cannot be justified as one would be operating on ten patients for the benefit of one.

Ethics statement

The author declares that this submission is in accordance with the principles laid down by the Responsible Research Publication Position Statements as developed at the 2nd World Conference on Research Integrity in Singapore, 2010. Ethics approval was not obtained (review article).

Declaration

The author declares authorship of this article and has followed sound scientific research practice. This research is original and does not transgress plagiarism policies.

Author contributions

The author performed all aspects of this work unaided: conceptualisation, study design, literature review, data capture, data analysis, first draft preparation, manuscript revision, finalisation of manuscript

ORCID

Dunn RN https://orcid.org/0000-0002-3689-0346

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