·临床研究·

S_2 骶髂螺钉的置入技术

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【摘要】 目的: 介绍 S_2 骶髂螺钉的置入技术。**方法**: 通过术前骨盆 CT 或标准骶骨侧位 X 线片测量确定 S_2 节段有足够的置钉空间。全麻后患者仰卧或俯卧, 常规消毒铺巾。首先在标准骶骨侧位透视像监视下将导针尖确定在 S_2 神经根管前缘线、椎体前缘线及 S_1 骶前孔下缘三者所围成的区域内并打入髂骨外板 1~2 mm, 然后在骨盆出口位透视像监视下引导导针沿 S_1 骶前孔下缘及 S_2 骶前孔上缘之间的区域行进, 在骨盆入口位透视像监视下确认导针位于 S_2 椎体及侧块前缘的后方, 将导针打至合适长度, 再次透视标准骶骨侧位像确认导针尖位于椎体前缘线后方及 S_2 骶神经根管前缘线的前方。之后沿导针测量长度, 钻孔、攻丝后拧入骶髂螺钉。**结果**: 应用此技术于不稳定型骨盆后环损伤患者 27 例, 置入 30 枚 S_2 骶髂螺钉。经术后骨盆出入口位 X 线及 CT 检查确认所有螺钉均位于 S_2 椎体及侧块骨质内, 置钉均准确。**结论**: S_2 骶髂螺钉置入技术安全且可复制, 可用于指导 S_2 骶髂螺钉的置入以增加不稳定型骨盆骨折后环固定的稳定性。

【关键词】 骨盆; 骨折; 骶髂关节; 骨折固定术, 内
DOI: 10.3969/j.issn.1003-0034.2015.10.007

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ABSTRACT　Objective: To introduce a technique pertaining to S_2 iliosacral screw insertion. **Methods**: The screw pathway was first measured on the preoperative pelvic CT scan or the standard sacral lateral radiograph to make sure the existence of the "safe zone" in the S_2 segment for screw insertion. Under general anesthesia, patients were positioned supine or prone, depending on the injury pattern of pelvic ring or associated injuries requiring concomitant operation. The operation field was routinely sterilized using iodine and subsequent alcohol solution and draped. The tip of a guide wire was inserted through a stab wound to the posterior outer iliac table, manipulated in the "safe zone" being enclosed by the anterior aspect of the S_2 nerve root tunnel, the anterior aspect of the sacral vertebrae, and the inferior aspect of the S_1 foramen under the guidance of the standard sacral lateral fluoroscopy, and then the tip was hammered one to two millimeters into the iliac cortex. The guide wire progressed along the trajectory between the inferior aspect of the S_1 foramen and the superior aspect of the S_2 foramen on the pelvic outlet fluoroscopic view, and then along the posterior to the anterior aspect of the S_2 sacral vertebrae and alae on the pelvic inlet fluoroscopic view with a predetermined length. At that moment, in order to ensure the safety, another standard sacral lateral view was imaged to detect the guide wire's tip which should locate posterior to the anterior aspect of the sacral vertebrae and anterior to the anterior aspect of the S_2 nerve root tunnel. Subsequently, the depth was measured, the trajectory was drilled and tapped, and the screw was inserted. Following the removal of the guide wire, the wound was irrigated and sutured. **Results**: Utilizing this insertion technique, there were 30 S_2 iliosacral screws in total being placed to stabilize the injured and unstable posterior pelvic ring in 27 patients. Each S_2 screw was accompanied by an ipsilateral S_1 screw. The S_2 screw location was completely intraosseous in all patients, which was verified by postoperative pelvic outlet and inlet radiographs and CT scans. The insertion accuracy was 100 percent in the present series. **Conclusion**: The S_2 iliosacral screw insertion technique is safe and reproducible to guide the placement of the S_2 screw, enhancing the stability for the compromised posterior pelvic ring.

KEYWORDS　Pelvic;　Fractures;　Sacroiliac joint;　Fracture fixation, internal
Zhongguo Gu Shang/China J Orthop Trauma, 2015, 28(10): 910-914　www.zggszz.com

随着骨盆环内固定相关的生物力学研究、骨盆成像技术及创伤骨科医师认识的进步, 经皮骶髂螺钉内固定技术被越来越广泛地应用于治疗不稳定型骨盆后环损伤[1-8]。自 20 世纪 80 年代末由 Matta 等[9]首先介绍一种由患者俯卧开放式将螺钉自髂骨

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外板后部臀肌粗隆附近跨过骶髂关节后方打入 S_1 椎体侧块内的技术以来，该技术由 Routt 等[10-12]逐渐发展并日趋成熟，至目前的患者可仰卧、俯卧甚至侧卧情况下经皮置入，且螺钉的长度也由打入骶骨侧块内发展到可贯通对侧髂骨外板[13]。进而使得此技术成为治疗不稳定性骨盆后环损伤的优选术式。然而，置钉技术的研究及发展主要集中在 S_1 骶髂螺钉的置入上，目前尚无明确的置钉技术来指导 S_2 骶髂螺钉的置入。本研究介绍 S_2 骶髂螺钉的置入技术。

1　研究对象

自 2014 年 4 月至 7 月，27 例不稳定骨盆后环损伤患者行经皮骶髂螺钉置入术治疗，共置入 S_2 骶髂螺钉 30 枚。其中男 19 例，女 8 例；平均年龄 41.3 岁。1 例 OTA-61B2.1，7 例 OTA-61B2.2，1 例 OTA-61B2.3，1 例 OTA-61B3.3（两侧各置入 1 枚 S_2 骶髂螺钉），15 例 OTA-61C1.3，1 例 OTA-61C2.3（两侧各置入 1 枚 S_2 骶髂螺钉），1 例 OTA-61C3.3（两侧各置入 1 枚 S_2 骶髂螺钉）。

2　研究方法

2.1　术前影像学评估

蔡鸿敏等[1]通过对标准骶骨侧位像[双侧髂骨高密度线（iliac cortical density，ICD）及髋关节分别重叠]的研究提出了“骶神经根管前缘线”（anterior aspect of sacral nerve root tunnel，AASNRT）的概念。该线在标准骶骨侧位像上可显影并被识别，其与椎体前缘线（anterior aspect of sacral vertebrae，AASV）及 ICD 共同围成 S_1 骶髂螺钉的平向“安全通道”（变异型上骶段无此通道[12]），其与 AASV、S_1 骶前孔下缘共同围成 S_2 骶髂螺钉的平向通道。一旦通过术前 CT 或标准骶骨侧位像的测量确定 S_2 节段存在足够的置钉空间（即平向“安全通道”）[1,3]，则可进行置钉手术（图 1a-1b）。

2.2　S_2 骶髂螺钉的置入方法

患者全麻后仰卧或俯卧于手术台。如患者仰卧，则垫高其腰骶部以增加置钉操作空间。常规消毒铺巾，对骨盆后环损伤先行闭合复位。闭合操作失败则行开放复位，维持复位后开始置钉操作。

首先，依照上述理论，在标准骶骨侧位透视像监视下将导针的进钉点确定在 S_2 AASNRT、AASV 及 S_1 骶前孔下缘三者所围成的“安全通道”内（图 1c-1d），并打入髂骨外板 1~2 mm。然后在骨盆出口位透视像监视下引导导针沿 S_1 骶前孔下缘及 S_2 骶前孔上缘之间的区域行进（图 1e-1f）。再在骨盆入口位透视像监视下确认导针位于 S_2 椎体及侧块前缘线的后方（图 1g-1h），将导针打至合适长度甚至根据需要可将其打透对侧髂骨外板[13]。之后沿导针测量长度，钻孔、攻丝及拧入骶髂螺钉。

蔡鸿敏等[2]发现因 S_1、S_2 椎体前缘存在共线（17.2%）、向腹侧成角（24.1%）及向背侧（58.7%）成角等，使得传统的骨盆入口位的定义（S_1、S_2 椎体前缘重叠）[9-12] 缺乏可靠性而需要将 S_1 入口位及 S_2 入口位区分开来。当 S_1、S_2 椎体前缘向背侧成角时，由于腰椎及 S_1 椎体的遮挡而使得 S_2 入口位较难获得。为了提高 S_2 骶髂螺钉的准确性而需要再次透视侧位像，以确认螺钉尖未向前突破 AASV 及向后突破 AASNRT（图 1i）。

2.3　术后影像学评估

术后常规拍摄骨盆出入口位 X 线片及 CT 判断螺钉位置（图 1j-1m）。

3　结果

应用上述置钉技术为 27 例不稳定骨盆后环损伤的患者置入 30 枚 S_2 骶髂螺钉，每枚 S_2 骶髂螺钉均结合有同侧 1 枚 S_1 骶髂螺钉。术后 X 线及 CT 片显示 30 枚螺钉完全位于 S_2 椎体及侧块骨质内（图 1j-1m），置钉均准确。

4　讨论

经皮骶髂螺钉置入术因其出血少、创伤小、固定效果好、并发症少等优点而成为目前治疗不稳定型骨盆后环损伤的首选方法[1-13]。相对于经 CT 引导[14]、计算机导航[15]等置钉方式而言，传统的经 C 形臂透视置钉方式应用最为广泛[1-2,4-13]。因骨盆后环解剖较复杂且存在变异[16-20]，分布有重要的神经血管[21-22]，而使得置钉难度大、风险高。S_2 骶髂螺钉的骨性通道常较 S_1 小，因而使得 S_2 骶髂螺钉的置入风险相对更高[23]。故绝大多数医师选择将骶髂螺钉置入 S_1 节段内[4,7-9]。临床研究发现，单枚骶髂螺钉内固定存在一定的失效率，多发生在完全不稳定型骨盆后环损伤（OTA-61C）的病例中[24]。所以，目前越来越多的医师倡导对损伤的骨盆后环进行“两点固定”（two points of posterior fixation）[25-26]，以保证固定效果，降低失效率。S_1、S_2 节段各置入 1 枚螺钉（两点固定）使螺钉较为分散，从而可更好地抵抗旋转、剪切应力，故此方式逐渐被报道并获得较好临床效果[19-20,25-26]。然而，目前无明确、规范的置钉技术来指导 S_2 骶髂螺钉的置入。

Osterhoff 等[25]将 S_2 骶髂螺钉的进钉点确定在 S_2 椎体上下终板平分面上，并位于该面与椎体后缘交点背侧数毫米。Moed 等[26]将进钉点确定在标准骶骨侧位像上 S_2 椎体上下终板、椎体前后缘所围成区域的中央（即 S_2 椎体中点）。由于缺乏对骶髂螺钉“安全通道”的理解及其在标准骶骨侧位像上的辨识，上述进钉点的选择存在盲目性、不确定性及不安全性。

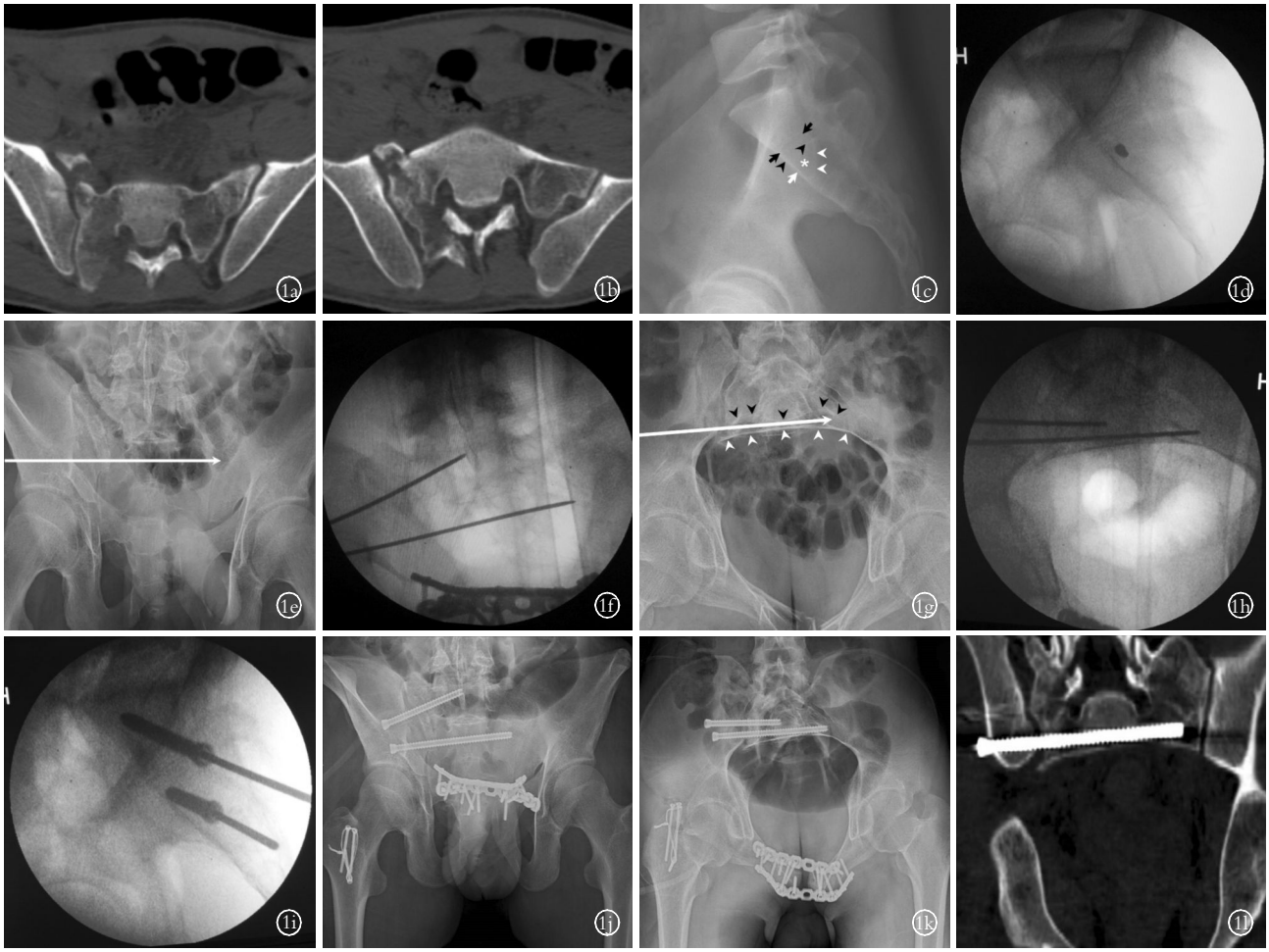

图 1　S_2 骶髂螺钉置入技术在 1 例 21 岁男性骨盆骨折(OTA-61C1.3)患者中的应用　**1a.** 术前骨盆轴向 CT 显示 S_2 节段有平向“安全通道”　**1b.** 术前骨盆轴向 CT 显示 S_1 节段无平向“安全通道”而有斜向“安全通道”　**1c.** 术前标准骶骨侧位 X 线片显示 S_2 节段的平向“安全通道”，其分别由 AASNRT（白箭头）、AASV(白箭)及 S_1 骶前孔下缘(黑箭头)围成，“＊”代表进钉点，S_1/S_2 椎间盘(黑箭)清晰可见　**1d.** 术中标准骶骨侧位透视像显示骶髂螺钉导针进钉点被确定在平向“安全通道”内　**1e.** 术前骨盆出口位 X 线片，白箭所模拟的骶髂螺钉导针位于 S_1 骶前孔下缘及 S_2 骶前孔上缘之间　**1f.** 术中骨盆出口位透视像显示 S_2 骶髂螺钉导针(长)位置良好　**1g.** 术前骨盆入口位 X 线片，白箭所模拟的骶髂螺钉导针位于 S_2 椎体及侧块前缘(白箭头)背侧，S_1 椎体及侧块前缘清晰可见(黑箭头)　**1h.** 术中骨盆入口位透视像显示 S_2 骶髂螺钉导针(长)位置良好　**1i.** 术中标准骶骨侧位透视像确认螺钉尖未向前突破 AASV 及向后突破 AASNRT　**1j, 1k, 1l, 1m.** 术后骨盆出口位(1j)及入口位(1k)X 线片、冠状位(1l)及矢状位(1m)CT 重建片显示 S_2 骶髂螺钉完全位于骨内。AASNRT：骶神经根管前缘；AASV：椎体前缘

Fig. 1　The application of the S_2 iliosacral screw insertion technique in a 21-year-old male patient with pelvic ring disruptions (OTA-61C1.3)　**1a.** A preoperative pelvic axial CT scan demonstrates that a transverse osseous “safe zone” exists in the S_2 segment　**1b.** The transverse osseous “safe zone” does not exist in the S_1 segment. While, the oblique osseous “safe zone” exists　**1c.** A preoperative standard sacral lateral radiograph clearly displays the S_2 transverse osseous “safe zone” which is enclosed by the AASNRT (white arrow heads), the AASV (white arrow) and the inferior aspect of the S_1 foramen (black arrow heads). The “＊” represents the start point of guide wire in the “safe zone”. The intervertebral disk of the upper two sacral segments is clearly imaged (black arrows)　**1d.** An intraoperative standard sacral lateral fluoroscopy demonstrates the start point being located in the S_2 transverse osseous “safe zone”　**1e.** A preoperative pelvic outlet radiograph. The long white arrow head simulates the desirable location of the guide wire, which is located between the inferior aspect of the S_1 foramen and the superior aspect of the S_2 foramen　**1f.** An intraoperative pelvic outlet fluoroscopy demonstrates that the S_2 guide wire (long) locates well　**1g.** A preoperative pelvic inlet radiograph. The long white arrow simulates the desirable location of the guide wire, which is located posterior to the anterior aspect of the S_2 sacral vertebrae and alae (white arrow heads). The anterior aspect of the S_1 sacral vertebrae and alae (black arrow heads) is also displayed clearly　**1h.** An intraoperative pelvic inlet fluoroscopy demonstrates that the S_2 guide wire (long) locates well　**1i.** An intraoperative standard sacral lateral fluoroscopy confirms that the tip of the screw doses not extrude the anterior cortical confine of the AASV and the posterior cortical limitation of the AASNRT　**1j, 1k, 1l, 1m.** Postoperative pelvic outlet (1j) and inlet (1k) radiographs and coronal (1l) and sagittal (1m) CT reconstructions confirm the excellent intraosseous S_2 screw location　AASNRT: anterior aspect of sacral nerve root tunnel, AASV: anterior aspect of sacral vertebrae

另外上述医师均未认识到 S_1、S_2 椎体前缘非共面对骨盆入口位成像的影响。尽管其置钉准确率较高(95.2%~100%),但不足以安全、规范地指导 S_2 骶髂螺钉的置入。

笔者将进钉点确定在标准骶骨侧位像上 AASNRT、AASV 及 S_1 骶前孔下缘三者所围成的平向“安全通道”内,此做法的优越性在于其一开始即将进钉点确定在安全区域内,进而在骨盆出入口位监视引导导针的正确指向及合适长度过程中可直接排除其突破骶神经根管、椎管及椎体前缘的可能性,从而确保置钉的安全。另外,为避免骨盆入口位的不可靠性,需要再次透视标准骶骨侧位像以确认导针或螺钉尖端未突破 AASNRT 及 AASV 的限制。关于 S_1、S_2 节段影像学研究表明,S_2 骶髂螺钉通道为平向[1,3,20](即平行于终板并同时平行于椎体及两侧块前缘),且当 S_1 节段存在变异(S_1 平向通道小或无)时的 S_2 平向通道更为宽广(相对 S_1 节段正常时)[20]。所以,在确定 S_2 节段存在平向“安全通道”后,通过器械将导针定位在标准骶骨侧位像上该“安全通道”内、调整成点状[27-28]并保持,则在后续的骨盆出入口位像监视下的操作变得更为简便(因为导针的指向已经确定,只需确定其长度即可)。

在上述技术的指导下,本组病例在置入 S_2 骶髂螺钉的同时均伴有同侧 1 枚 S_1 骶髂螺钉的置入,从而实现了不稳定骨盆后环损伤患侧的两点固定,增强了固定效果。有学者建议两点固定的适应证为完全不稳定型骨盆后环损伤(OTA-61C)[26,29-30](本组 27 例中有 17 例),骨盆后环损伤合并骨量缺失或骨量减少(osteoporosis)者,依从性差者或重体力劳作者[25-26]。因患者常不按时随访,甚至失访,及医患关系等方面的原因,笔者通常在确保安全的情况下将两点固定适应证扩大至所有不稳定型骨盆后环损伤(OTA-61B 及 C)。有研究表明,同侧置入 2 枚骶髂螺钉(两点固定)的固定效果优于单枚螺钉(单点固定),而且 S_1、S_2 节段各置入 1 枚螺钉的固定效果优于 S_1 节段置入 2 枚螺钉[19]。S_1、S_2 节段各置入 1 枚螺钉使得螺钉较为分散,从而可更好地抵抗旋转、剪切应力,因而获得较好的临床效果[19-20,25-26]。复习相关文献发现,几乎所有的 S_2 骶髂螺钉的置入均被用作两点固定的第 2 点而未发现单独使用者[19-20,25-26,31]。

总之,术前测量确定 S_2 节段存在安全的置钉通道,则本研究的置钉技术可安全、规范地指导 S_2 骶髂螺钉的置入,有可重复性。不稳定性骨盆后环损伤常需要“两点固定”,S_2 骶髂螺钉通常被用作两点固定的 1 个点与 S_1 骶髂螺钉配合使用,以增强固定效果,降低失效率。

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(收稿日期: 2014-12-28　本文编辑: 连智华)