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ORIGINAL PAPER

Indications for the monosegmental stabilization of thoraco-lumbar spine fractures

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Abstract

Purpose To evaluate the efficacy and to underline the right indications of the posterior monosegmental stabilization for the treatment of thoraco-lumbar spine fractures.

Method Twenty patients underwent a monosegmental stabilization at our Institution and were retrospectively reviewed with a minimum follow-up of two years. All the patients had a clinical and radiological assessment before, after the surgery and at final follow-up. All data were evaluated by one independent observer. Data collected were Denis pain and work scale, somatic kyphosis (SK), somatic height (SH), and compression percentage (CP).

Results The mean pre-operative SK angle measured between the upper and lower end plate of the fractured vertebra was 23.6°. The mean SK immediately after surgery was 12.8° and at final follow-up was 13.9°. The mean pre-operative SH was 21.9 mm, the mean value after surgery was 26.5 mm, and at final follow-up was 24.8 mm. The mean pre-operative CP was 66.7%, the mean value after surgery was 80.9%, and at final follow-up was 75.3%. At final follow-up, 75% of the patients had no pain or moderate pain and 95% of the patients returned to a full time work.

Conclusions Monosegmental stabilization with fusion is a safe and effective method to treat well selected thoracolumbar spine fractures. The right indications are type A1, type B2, and type A3 with a load sharing of less than 7 points and some very well selected type C fractures in which there is not lateral and rotatory displacement.

Keywords Monosegmental stabilization · Pedicle fixation · Posterior approach · Thoraco-lumbar fractures · Spine fractures

Introduction

Primary golas of spinal fractures treatment are to restore stability, to decompress and protect neural structures, to prevent spinal deformity, and to obtain an early mobilization of the patient.

Non-operative treatment for amielic spinal fractures with bed rest and bracing has been proposed with variable results by many authors.

Surgical treatment can be considered in cases with vertebral instability, spinal deformity and in cases with neurological compression.

Posterior pedicle screws fixation is the gold standard of treatment for the majority of thoraco-lumbar spine fractures. Anterior approach can also be considered in selected patients that need anterior decompression and support.

The primary objective of posterior vertebral stabilization is to be able to achieve the greatest possible stability by blocking the lowest number of possible vertebrae.

The number of levels to stabilize depends on several factors including the type of fracture, the anterior column involvement, and the presence of osteoporosis. These factors are crucial for the right choice of treatment, in fact high-grade anterior somatic comminution or osteoporosis impose the use of longer instrumentation in order to minimize the risk of hardware failure.

The monosegmental stabilization represents the shortest form of posterior instrumentation that exists, having the enormous advantage of blocking only one functional vertebral segment.

Many authors report the advantages of the monosegmental stabilization with good functional outcomes [1–3].

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It is a type of instrumentation with a very short lever arm and so very stable with high resistance to axial compression forces, but it has very selected indication.

Monosegmental instrumentation cannot be used for the treatment of all vertebral fractures patterns and indications must be carefully evaluated in order to minimize the risk of failure.

This retrospective study offers the radiographic and clinical results of monosegmental stabilization for the treatment of very selected thoracolumbar spine fractures with minimum follow-up of two years.

We report our experience in the use of monosegmental stabilization to underline its importance in fracture treatment and to report the right indications in which it can be used.

Materials and methods

We retrospectively reviewed 20 patients between January 2012 and December 2015 treated in our Institution with a monosegmental stabilization and fusion for traumatic thoraco-lumbar spine fracture.

There are ten men and ten women with a mean age of 38.8 years and a minimum follow-up of two years.

All the patients underwent a monosegmental fixation with the same fixation system; all of them received also homologous bone graft or bone substitute in order to achieve a solid fusion.

The thoraco-lumbar junction was involved in 85% of the cases (17/20) and the levels involved were T12 in seven cases (35%), L1 in ten cases (50%), L2 in two cases (10%) and L3 in only one case (5%).

According to AO classification system [4], we treated 14 type A (5 type A1 and nine type A3), three type B (all type B2), and three type C fractures.

According to load sharing classification, all the fractures in this series were less than 7 points [5].

All patients were neurologically intact and all the fractures were caused by trauma (sports injury, fall from a height and traffic accident). Table 1 shows patient demographic.

All patients ($n = 20$) were examined pre-operatively, immediate post-operatively and at final follow-up (minimum 2 years) with standard X-ray; CT scan and MRI were performed only in the pre-operative assessment. The minimum follow-up was two years.

All data were evaluated by one independent observer by using the same Impax software.

Data collected were somatic kyphosis (SK), somatic height (SH), and compression percentage (CP) measured in relation to the height of the underlying healthy vertebra (Fig. 1).

Results

All the 20 patients were reviewed immediately after surgery and at minimum final follow-up of two years. Clinical and radiological data were collected.

Table 1 Patient demographics

Patient n°	Patient initial	age	sex	Type of injury	Fracture level	AO Classification
1	CL	28	F	Sport injury	T12	B2
2	PS	26	M	Sport injury	L1	B2
3	VVJI	54	F	Fall from a height	L1	A3
4	MG	64	M	Traffic accident	T12	A3
5	SI	48	F	Sport injury	T12	B2
6	SO	37	F	Fall from a height	L2	A1
7	NG	46	M	Fall from a height	L2	A3
8	FV	41	M	Traffic accident	L1	A3
9	AE	53	M	Traffic accident	L1	A3
10	CS	35	F	Fall from a height	L1	A1
11	NC	30	F	Fall from a height	L3	A3
12	BV	32	M	Sport injury	T12	C
13	PE	16	F	Sport injury	L1	C
14	PL	54	F	Traffic accident	L1	A3
15	CA	18	F	Sport injury	T12	C
16	BP	54	F	Traffic accident	T12	A3
17	EM	48	M	Fall from a height	L1	A3
18	GKJE	34	M	Fall from a height	T12	A1
19	CF	26	M	Sport injury	L1	A1
20	BD	33	M	Fall from a height	L1	A1

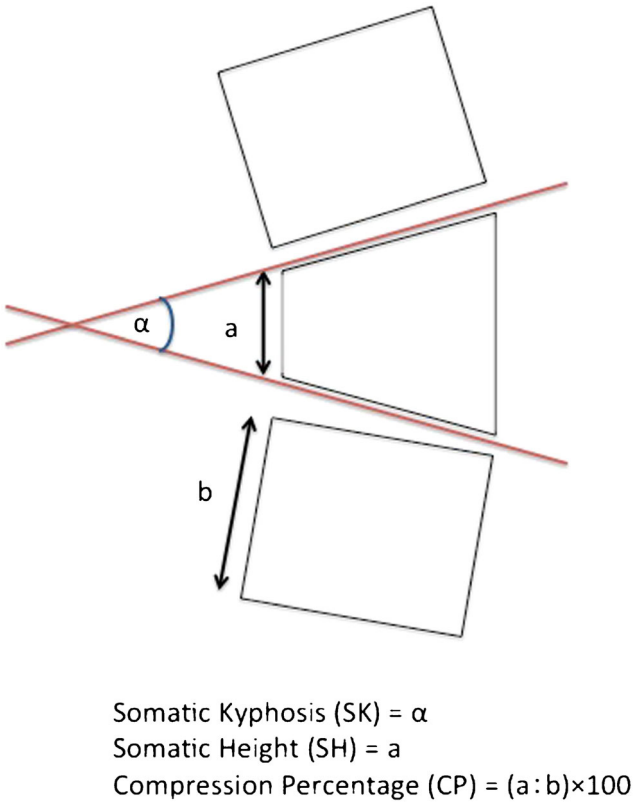

Fig. 1 Schematic representation of the different x-rays measurement

The mean operative time was 84.6 minutes and the mean intra-operative blood loss was 188.4 ml.

The mean pre-operative SK angle measured between the upper and lower end plate of the fractured vertebra was 23.6°. The mean SK immediately after surgery was 12.8° and at final follow-up was 13.9°.

We observed a global mean improvement of the kyphotic vertebral deformity of 10.8° immediately after surgery with a mean worsening of the vertebral kyphosis of 1.1° at final follow-up.

In two cases (n° 9 and 14), we observed a higher increasing of the kyphotic deformity at final follow-up if compared with the post-operative values. In case 9, it increases of 4° while in case 14 it increases of 7.3°; both cases were type A3 fracture according to AO Classification system (Table 2).

Table 3 shows the results of somatic height (SH) and compression percentage (CP) measured before, after the surgery and at final follow-up.

The mean pre-operative SH was 21.9 mm, the mean value after surgery was 26.5 mm, and at final follow-up was 24.8 mm. There was a mean SH improvement of 4.6 mm after surgery with a mean loss of 1.7 mm at final follow-up.

The mean pre-operative CP was 66.7%, the mean value after surgery was 80.9%, and at final follow up was 75.3%. We observed a mean CP improvement after surgery of 14.2% with a mean loss at final follow-up of 5.6%.

Figure 2 shows the pre-operative assessment of an L2 fracture. This patient had a fall from a height with a consequent incomplete burst fracture (type A3) of the body of L2 with a load shearing classification of 5 points. Figure 3 shows the post-operative lateral x-ray (left) and the 2 years follow-up (right) of the same patient after the monosegmental stabilization. Pictures demonstrate a good correction of the SK and SH remaining stable at two years.

Figure 4 shows the monosegmental stabilization for the treatment of a T12 type B2 fracture. From left to right, it is possible to see the posterior ligamentous lesion treated with a good restoration of the posterior tension band after the surgery.

Figures 5 and 6 show the pre-operative and 2-years follow-up assessment of a type C fracture with a perfect reduction of the spinal subluxation with restoration of good stability.

All patients were reviewed at final follow up according to Denis pain and work scale [6].

Eight patients had no pain (P1), seven had occasional minimal pain (P2), four patients had moderate pain with occasional medication (P3), and only one patient had moderate to severe pain with changes in activities of daily living (P4).

Fifteen patients were able to return to their previous employment (W1 and W2); five of them returned to heavy labour while ten to sedentary labor. Four patients were unable to return to previous employment but works full time at new job (W3) and only 1 patient was unable to return to full time work (W4). None of the patients had to leave the job.

We did not observe any major complication and only one patient underwent hardware removal three years after surgery for screw loosening.

Discussion

The right treatment of an instable thoraco lumbar spine fracture is still a matter of debate.

Conservative treatment is to be considered for stable fractures and some authors found that there was no significant difference in functional outcome between operative and non-operative approaches at final follow-up [7].

Many authors reported the advantages of the surgical treatment, particularly with regard to early recovery and prevention of neurologic deterioration [6, 7].

Although anterior approach can reduce the risk of kyphotic deformity recurrence with hardware failure, it is associated with increased morbidity and higher risk of potential complications if compared with posterior approach.

Posterior pedicular fixation still remains the gold standard of treatment for thoracolumbar spine fractures.

Main goals of the posterior approach are to have fracture reduction with a stable fixation, in order to achieve

Table 2 X-rays measurement of Somatic kyphosis (SK). Cases 9 and 14 had a significant worsening of the SK at final follow-up. Both cases were A3 type fractures caused by high energy trauma (traffic accident)

Patient n°	Fracture level	Preop SK (°)	Postop SK (°)	Last follow-up SK (°)
1	T12	26,9	15,1	16.1
2	L1	22,4	12,1	13
3	L1	26,3	16,2	16.9
4	T12	29,3	16,5	18.2
5	T12	18,2	8,5	10.2
6	L2	31,3	18,2	20.1
7	L2	32,3	22	23
8	L1	32,6	19,8	20.6
9	L1	31,8	18,2	22.2 (+ 4°)
10	L1	26,2	14,5	16.4
11	L3	23,4	5,4	5.2
12	T12	15,1	11,2	11.2
13	L1	25,4	12,4	13.1
14	L1	19,6	4,6	11.9 (+ 7.3°)
15	T12	15,4	8,6	8.1
16	T12	18	14,6	14.4
17	L1	22,2	11,5	11
18	T12	17,2	10,1	10
19	L1	20	9	9.2
20	L1	18,1	7,9	7.5

early mobilization and to prevent post-traumatic deformity or neurologic deterioration.

Minimally invasive procedure and percutaneous stabilization in thoracolumbar trauma has been increasingly

Table 3 X-rays measurement of somatic height (SH) and compression percentage (CP)

Patient n°	Fracture level	Preop		Postop		Last FU	
		SH (mm)	CP (%)	SH (mm)	CP (%)	SH (mm)	CP (%)
1	T12	25.2	78,5,046,729	27.9	84,54,545,455	27	83,85,093,168
2	L1	17.9	56,82,539,683	25.8	80,625	24.1	76,02523659
3	L1	17.7	56,19,047,619	20.6	63,97,515,528	17	53,125
4	T12	18.1	54,68,277,946	25.6	77,81,155,015	23.8	72,12,121,212
5	T12	18.1	63,73,239,437	22.2	77,89,473,684	19.4	68,79,432,624
6	L2	25.9	78,01204819	29,.9	92	27.8	88,25,396,825
7	L2	26.4	75	28.7	76,94,369,973	26.9	72,7,027,027
8	L1	26.1	78,61,445,783	29.3	88,51,963,746	27.9	84,80,243,161
9	L1	24	75,94,936,709	28.9	92,62,820,513	27,2	86,90,095,847
10	L1	16.3	53,44,262,295	22.4	74,41,860,465	19.2	64,4,295,302
11	L3	25	73,52,941,176	32.7	95,61,403,509	28,2	82,69,794,721
12	T12	25.6	78,76,923,077	26.4	89,79,591,837	24.5	80,59,210,526
13	L1	14.8	56,92,307,692	22.7	71,15,987,461	22.5	71,42,857,143
14	L1	17.3	51,18,343,195	26.2	83,43,949,045	23.3	66,00566572
15	T12	23.2	69,87,951,807	28.7	86,96,969,697	26	79,51,070,336
16	T12	20.4	63,55,140,187	19.8	71,73,913,043	20.5	67,8,807,947
17	L1	19.4	55,11,363,636	23.2	69,46,107,784	23	69,6,969,697
18	T12	23.9	69,67,930,029	25	74,4,047,619	24.8	74,69,879,518
19	L1	28.2	74,01574803	32.3	81,7,721,519	31	79,48,717,949
20	L1	26	70,84,468,665	31.9	84,84,042,553	31.2	83.2

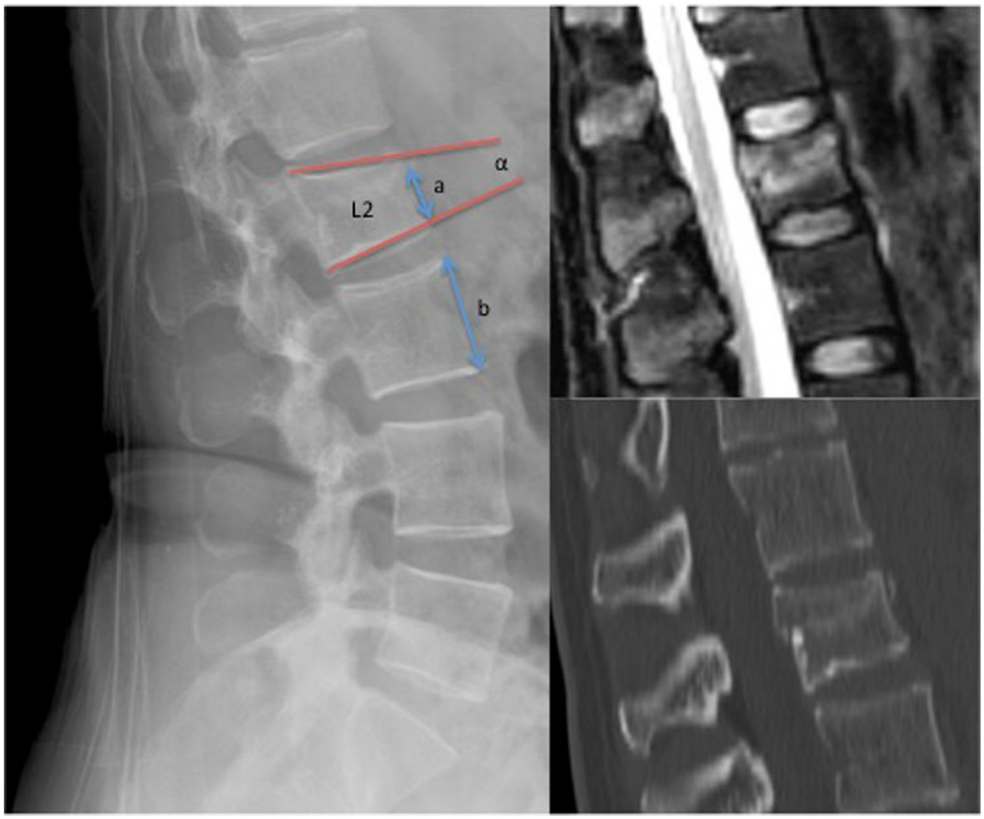

Fig. 2 L2 type A3 fracture of a 46-year-old man caused by a fall from a height (case n° 7). MRI and CT scan showed an incomplete burst fracture with involvement of the posterior wall

used since the beginning of the century when Assaker first reported the use of this surgical technique in spinal trauma [8].

Sun et al. in 2017 reported an important literature meta-analysis on percuraneous versus open treatment of thoraco-lumbar fractures without neurological deficit. They concluded that the open approach was superior to percutaneous approach in terms of post-operative Cobb angle and vertebral body deformity correction [9].

Monosegmental open stabilization is the shorter kind of fixation we have to treat a spinal fracture. Because it fixes only one functional spinal unit, it can be considered the most minimally invasive procedure to treat a thoraco-lumbar fracture.

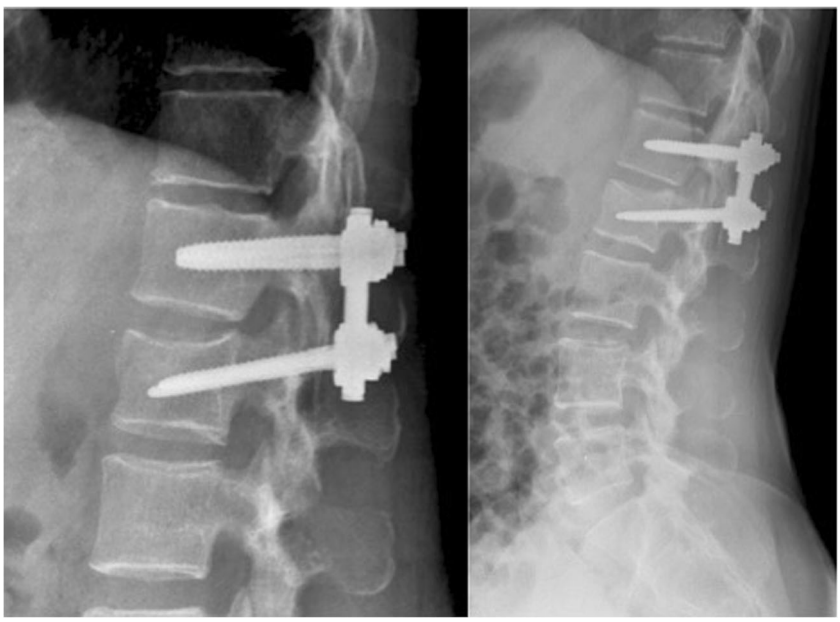

Fig. 3 Immediate pos-operative lateral x-ray (left) and 2-year follow-up (right) of case n° 7. Pictures show a good kyphosis correction remaining stable at last follow up

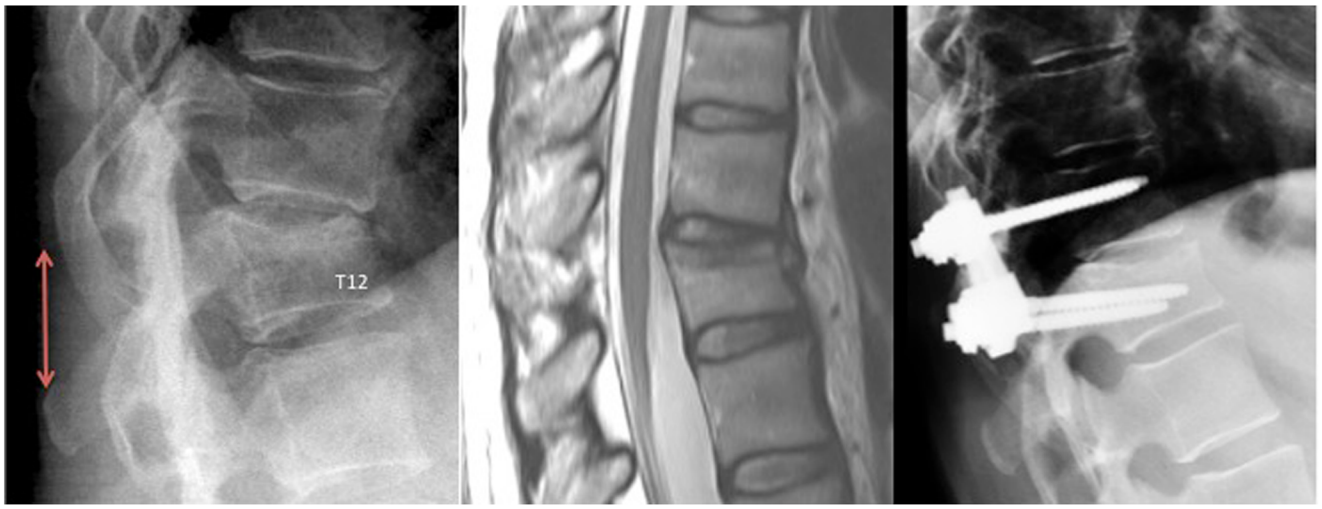

Fig. 4 T12 type B2 fracture of a 48-year-old woman caused by sport injury (case n°5) treated with a monosegmental stabilitazion with good restoration of the posterior tension band

This surgical technique must be very carefully indicated and sharply conducted in order to avoid its failure.

For well selected type of fracture, the monosegmental fixation has the same radiological results of bisegmental fixation in terms of vertebral body height restoration and correction of the kyphotic deformity [10, 11]. Both the surgical techniques are effective and reliable for selected thoracolumbar burst fractures [3].

Monosegmental stabilization cannot be use in complete burst fractures (type A4) and the McCormak classification system helps to describe the amount of bony comminution in order to predict hardware failure [5, 12].

Lyu et al. [13] reported that percutaneous fixation provides the same reduction effect as open fixation in the treatment of type A thoracolumbar fractures with less operation-related

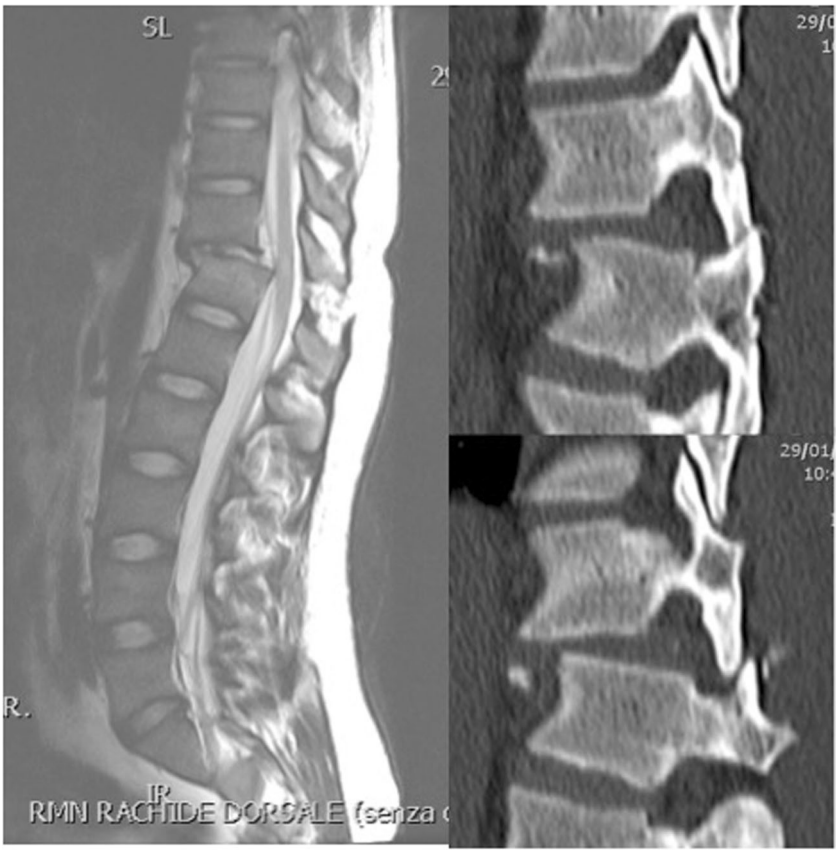

Fig. 5 Thirty-two-year-old man with T11 on T12 dislocation (type C fracture) caused by sport injury. Pre-operative picture shows the dislocation of the spine only in the sagittal plane

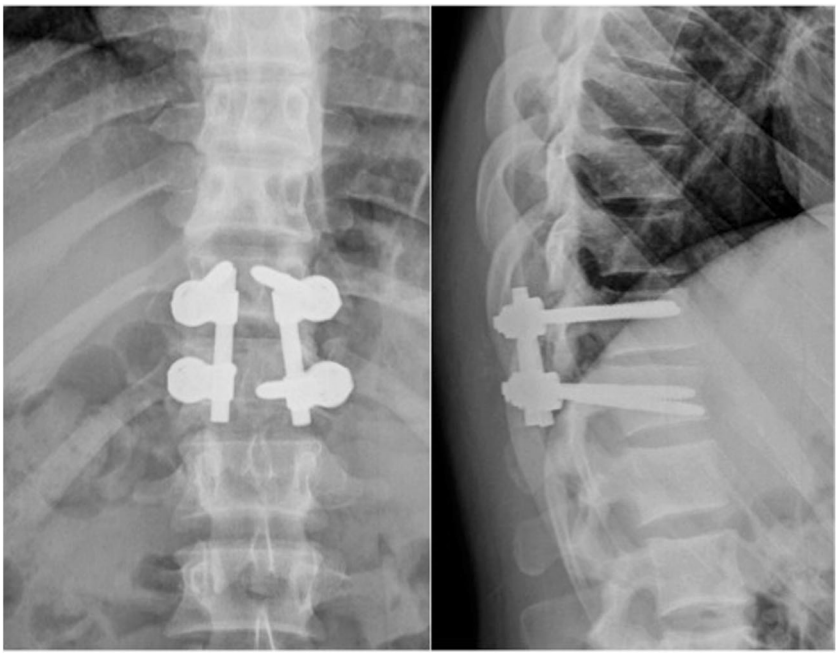

Fig. 6 X-rays taken at 2 years of follow-up of case n° 12. There is a complete reduction of the spinal subluxation with a good spinal stabilization

trauma and that the efficacy of three-level and two-level percutaneous fixation is not significantly different.

We believe that in well selected type A3 fractures, the open monosegmental stabilization leads to a less invasive clinical result if compared with a bisegmental percutaneous fixation.

In this study, we observed a mean improvement of the somatic kyphosis at 2 years of follow-up of 9.7° (mean value of the SK improved from 23.6° to 13.9°).

In two cases (n° 9 and 14), we observed a higher increasing of the kyphotic deformity at final follow up if compared with the postoperative values. In case 9, it increases of 4° while in case 14 it increases of 7.3°; both cases were type A3 fracture.

These results showed that type A3 fracture are at higher risk of loss of SK correction at 2-year follow-up.

The mean somatic height improvement at final follow-up was of 2.9 mm (from 21.9 to 24.8 mm) with an increasing of the compression percentage of 8.6% (from 66.7 to 75.3%).

In four patients (n° 2, 4, 11, 14), we observed the biggest increasing of CP immediately after surgery with a mean value of 25.2%; three of them (n° 4, 11, 14) had a type A3 fracture. In the same three patients with type A3 fracture, we observed the biggest amount of reduction of the CP from the postoperative value to the 2-year follow-up value, with a mean loss of correction of 12%. These patients had also a load sharing classification of 7 points.

These results suggest that type A3 fracture with a load sharing of 7 points are at higher risk of loss of CP correction at 2 years of follow-up and that in these cases the use of the monosegmental stabilization must be carefully evaluated.

All three type C fractures we treated were a pure sagittal dislocation of the spine without any kind of lateral or rotatory displacement.

Osteoporotic vertebral fractures must be considered as a contraindication for the monosegmental stabilization because of the high risk of hardware failure, so in these patients different surgical techniques must be indicated.

Percutaneous vertebroplasty has proven to be more effective than conservative treatment in terms of clinical radiological results for osteoporotic compression fractures [14].

Katsumi et al. [15] report that short-segment vertebroplasty with posterior instrumentation and fusion without neural decompression for the treatment of osteoporotic collapsed vertebra with canal compromise less than 40% can achieve a high union rate of collapsed vertebra with significant improvement of back pain and neurological status. They concluded that spinal stabilization rather than neural decompression is essential to treat osteoportic vertebral collapse.

Vertebral osteoporotic collapse is an absolute contraindication for the use of the monosegmental stabilization.

Clinical results at 2 years of follow-up showed that 15/20 patients (75%) had no pain or moderate pain (P1 and P2) according to Denis pain scale and that 19/20 (95%) returned to a full time work (W1, W2, and W3) according to Denis work scale.

The AO spine injury classification system used in combination with the load sharing classification points system are very useful tools to identify the right fracture pattern in which a monosegmental stabilization can be indicated.

The monosegmental stabilization with fusion can be indicated with excellent clinical and radiological results in type A1, B2, and A3 fractures with less than 7 points of load sharing.

Type C fractures can be treated with monosegmental stabilization only for sagittal plane dislocation; lateral displacement with or without rotatory component must be treated with longer fixations.

Conclusions

From this retrospective clinical and radiological study, we can conclude that monosegmental stabilization with fusion is a safe and effective method to treat well selected thoracolumbar spine fractures.

The monosegmental stabilization allows to block only one functional spinal unit and it can be considered much less invasive than a percutaneous bisegmental stabilization.

The right indications for the surgical procedure are type A1, type B2, and type A3 with a load sharing of less than 7 and some very well selected type C fractures in which there is not a lateral and rotatory displacement.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies which need ethical approval.

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