Impact of Screw Type on Kyphotic Deformity Correction after Spine Fracture Fixation: Cannulated versus Solid Pedicle Screw

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Abstract

Study design: Retrospective review

Objectives: To detect the effect of cannulated and solid screws on the local kyphotic angle, vertebral body height, and superior and inferior angles between the screw and the rod in the surgical management of thoracolumbar fractures.

Summary of Background Data: Thoracolumbar fractures are quite common in Qatar, and add a significant burden to the health-care system. The 2 types of fixation techniques used in the surgical management of thoracolumbar fractures are the conventional or open technique and the minimally invasive surgical technique with either cannulated or solid screw.

Methods: The medical charts of patients with thoracolumbar fractures who underwent pedicle screw fixation with cannulated or solid pedicle screws and were followed up from January 2011 to December 2015 were retrospectively reviewed.

Results: A total of 178 cases [average age, 36.1 ± 12.4 years; male, 142 (84.3%); female, 28 (15.7%)] of thoracolumbar fractures that were operated and followed up at Hamad Medical Corporation were grouped into two based on screw type: cannulated and solid core. The most commonly affected level was L1, followed by L2 and then D12. Surgical correction of the local kyphotic angle showed statistical significance, whereas the average loss of correction of local kyphotic angle did not show statistical significance. Surgical correction of reduction of vertebral body height showed statistical significance, whereas the average loss of correction of reduction of vertebral body height did not show statistical significance. The difference between postoperative and final follow-up values of the superior and inferior angles was not statistically significant.

Conclusion: Solid screws are superior in providing increased correction of the kyphotic angle and height of the fractured vertebra, compared with cannulated ones, but there was no difference between the 2 screws in maintaining the superior and inferior angles of the screw with the rod.

Level of Evidence: Level III

Key words: Solid screw, cannulated screw, thoracolumbar fractures, kyphotic angle.

Introduction

Traumatic spine fractures are common injuries that result from many causes, particularly falls from a high and road traffic accidents. If not treated properly, they can cause major disability, and approximately 12% of patients who presented to the trauma unit in the emergency department of Hamad Medical Corporation are classified in this category [1].

For unstable spine fractures, fixation is necessary, which is accomplished with either the open traditional technique or the minimally invasive surgery (MIS) technique, which is increasing in popularity among spine surgeons because it has less risk of blood loss, decreased operation time, and decreased postoperative pain [2-3].

Cannulated pedicle screws (CS), which use a guide wire for the insertion of the screw, is considered the cornerstone of the MIS technique, whereas in the open technique, the use of solid-core screws (SCS) remains a valid option[4-5] (Figure 4-5) .

To our knowledge, many studies investigate the physical characteristics of cannulated and solid pedicle screws, such as bending performance, static and dynamic load to failure, and pullout strength, using biomechanical tests on cadaveric or constructed modules, but a few were done on the radiological or clinical differences between those screws in non-English literature[4-9].Our aim was to compare the correction of the local kyphotic angle and the vertebral body height between the 2 types of screws and detect their effect on the superior and inferior angles of the screw with the rod.

Methods

A retrospective review of the medical charts of all patients with thoracolumbar fractures who underwent pedicle screw fixation with cannulated or solid-core pedicle screws and followed up at the orthopedic department at Hamad Medical Corporation, Doha, Qatar, from January 2011 to December 2015, after the approval of the medical research center.

Data on general demographic characteristics (age and sex), comorbidities, injury characteristics (mode of trauma, level of injury, and fracture classification), surgery-related parameters (open versus MIS, cannulated versus solid-core screw), and radiological parameters (superior and inferior angles between the screw and the connecting rod, local kyphotic angle and vertebral body high) were collected during different follow-up intervals (preoperative, postoperative, and at follow-up at 3, 6, and 9-12 months).

The local kyphotic angle is the angulation between the superior and inferior plates of the fractured vertebra (Figure 1), and the vertebral body height was calculated by dividing the anterior wall height over the posterior wall height and then multiply by 100 (Figure 2). The superior angle is the angle between the rod and the superior screw, whereas the inferior angle is the angle between the rod and the inferior screw (Figure 3).

Indications for surgery were increase in kyphotic angle of more than 30°, loss of vertebral body height of more than 50%, or neurological deficit. The choice between open and MIS surgery depended on the surgeon's preference and experience, whereas the choice between cannulated and solid screws depended on availability.

Frequency (percentage) and mean ± SD or median and range were used for categorical and continuous values, as appropriate. Descriptive statistics were used to summarize demographic characteristics, injury characteristics, surgery-related parameters, and radiological parameters. Chi-square test and Fisher exact test were used to detect the associations between 2 or more qualitative variables, whereas unpaired t and Mann-Whitney U tests were used for quantitative data. A 2-sided p value <.05 was considered statistically significant. All statistical analyses used SPSS version 22.0 (SPSS, Chicago, IL, USA) and Epi Info™ 2000 (Centers for Disease Control and Prevention, Atlanta, GA, USA).

Results

A total of 178 cases [average age, 36.1 ± 12.4 years; male, 142 (84.3%); female, 28 (15.7%)] of thoracolumbar fractures were operated and followed-up at Hamad Medical Corporation. The most commonly affected level was L1 in 37.1%, followed by L2 in 18% and then D12 in 17.7% (Table 1).

The average preoperative, postoperative, and final follow-up local kyphotic angles of the fractured vertebra were 17.4° ± 8.9°, 8.6° ± 6.9°, and 11.6° ± 6.4° in the cannulated screw group, respectively, and 20.1° ± 10.7°, 7.1 ± 5.6°, and 7.5° ± 6° in the solid screw group, respectively. Surgical correction (ie: the difference between the preoperative and postoperative local kyphotic angles) was 8.8° ± 10.4° and 13° ± 11.2° in the cannulated and solid groups, respectively, which was statistically significant (p = .014), whereas the average loss of correction (ie: the difference between the final follow-up and postoperative local kyphotic angles) was 4.2° ± 5.9° and 9.5° ± 5.5° in the cannulated and solid groups, respectively, which was not statistically significant (p = .117) (Table 2 and Figure 6).

The average intraoperative, postoperative, and final follow-up reductions in vertebral body height of the fractured vertebra were 39.6% ± 28.2%, 23.5% ± 13.3%, and 26% ± 15.1%in the cannulated screw group, respectively, and 41.5% ± 27.6%, 20.1% ± 12.6%, and 20.1% ± 15.5% in the solid screw group, respectively. The surgical correction of reduction of vertebral body height was 16.1% ± 14.9% and 21.4% ± 15% in the cannulated and solid groups, respectively, which was statistically significant ($p = .024$), whereas the average loss of correction of reduction of vertebral body height was 18% ± 13% and 20.2% ± 7.1% in the cannulated and solid groups, respectively, which was not statistically significant ($p = .682$) (Table 2 and Figure 6).

The difference between the postoperative and final follow-up superior and inferior angles was not statistically significant ($p = .324$ and $p = .838$, respectively), with an average superior angle of 4.5° ± 0.7° and -0.3° ± 6° in the cannulated and solid groups, respectively, and an average inferior angle of 1.5° ± 4.9° and 0.8° ± 3.5° in the cannulated and solid groups, respectively (Table 2 and Figure 6).

Discussion

Thoracolumbar fractures are quite common in Qatar, which add a significant burden to the health-care system. Qatar is a growing country with a rapidly growing population and infrastructure, and current statistics in Hamad Medical Corporation, which is the main tertiary hospital in Qatar, show that approximately 200 cases present with traumatic spinal injuries annually, which are primarily due to motor vehicle accidents and falls from a high place, making traumatic spinal fracture the leading cause of disability in our population [1].

Literatures showed no differences in vertebral body height local kyphotic angle correction between the open and MIS techniques, but the latter has shorter operative time and less blood loss [2-3].

To our knowledge, this is the first study to compare the effect of cannulated and solid-core screws on the local kyphotic angle and vertebral body height after spine fracture fixation. Many studies compared the biomechanics of cannulated and solid-core screws, and they showed that ultimate load, yield strength, and cycles to failure were significantly lower in cannulated screw than in solid-core screw [4-5-7-8]. Another study performed biomechanical tests to compare the bending performance between solid-core and cannulated screws and found that the latter has significantly poorer bending performance [6]. Other studies compared the effect of poly-axial versus mono-axial screw on the stability of the construct after fixation, and they showed that incorporating a poly-axial pedicle screw did not significantly decrease the construct's stiffness [9].

The superior and inferior angles, which reflect the bending of screw and impending failure and broken. Our study revealed changes in the superior angle during follow-up, with statistically significant difference between cannulated and solid screws in the first ($p = .001$), second ($p = .001$), and last follow-ups ($p = .006$), but no statistical difference between postoperative and last follow-up ($p = .324$). No statistically significant difference was detected in the inferior angle during the first, second, and last follow-ups ($p = .125$, $p = .165$, and $p = .092$, respectively) or in the superior angle between postoperative and last follow-up ($p = .838$) (Table 2).

We use both techniques in our hospital, and generally, we use poly-axial cannulated screws in MIS techniques and mono-axial solid screws for the open technique (Table 2).

One of the most important limitations of the current study is the lack of correlation of the radiological findings with the functional outcome and complication rate. Another limitation is the short follow-up duration; thus, long-term follow-up studies are necessary to detect long-term complications and failure of both types of screws.

Conclusion

Solid screws, compared with cannulated ones, are superior in providing increased correction of the kyphotic angle and height of the fractured vertebra; however, no difference was noted between cannulated and solid-core screws in maintaining the superior and inferior angles of the screw with the rod.

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Table 1 :

	Total	Cannulated	Solid	P-value
Number	178	100 (56.2%)	78 (43.8%)	
Age	36.1 ± 12.4	37.8+-14	34.3+-9.9	0.067
Gender				0.473
Male	150 (84.3%)	86 (57.3%)	64 (42.7%)	
Female	28 (15.7%)	14 (50%)	14 (50%)	
technique				0.001
Open	110 (61.8%)	32 (29.1%)	78 (70.9%)	
MIS	68 (38.2%)	68 (100%)	0	
Level				
Thoracic Spine	52 (29.2%)			
Lumber Spine	126 (70.8%)			

Table 2

	Cannulated	Solid	CI	P-value
Local Kyphotic angle				
Pre-op	17.4 ±8.9	20.1 ±10.7	-0.16 _ 5.7	0.065
Post-op	8.6 ±6.9	7.1 ±5.6	-3.4 _ 0.38	0.116
Follow up 1	11.5 ±6.6	9.2 ±6.7	-4.40 _ -0.04	0.046
Follow up 2	10.5 ±6.2	8.3 ±6	-4.92 _ 0.51	0.111
Follow up 3	11.6 ±6.4	7.5 ±6	-11.34 _ 3.23	0.249
Between pre-op and post op	**8.84 ±10.4**	**13 ±11.2**	0.86 _ 7.44	0.014
Between post-op and final follow up	**4.2 ±5.9**	**9.5 ±5.5**	-1.54 _ 12.25	0.117
Vertebral body height				
Pre-op	39.6 ±28.2	41.5 ± 27.6		
Post-op	23.5 ±13.3	20.1 ± 12.6	-7.3 _ 9.47	0.085
Follow up 1	29.4 ±14.2	21.4 ± 13.7	-12.6 _ -3.4	0.001
Follow up 2	28.4 ±12.4	20.0 ± 13.2	-14.1 _ -2.7	0.004
Follow up 3	26.0 ±15.1	20.1 ± 15.5	-24.1 _ 12.3	0.498
Between pre-op and post op	**16.1 ±14.9**	**21.4 ± 15.0**	97.0 _ 9.9	0.024
Between post- op and final follow up	**18.0 ±13**	**20.2 ± 7.1**	-9.3 _ 13.7	0.682
Superior angle				
Intra op	80.8 ± 6.3	87.1 ± 4.9	4.2_8.3	0.001
Post-op	80.8 ± 5.7	88.4 ± 5.4	5.9_9.2	0.001
Follow up 1	79.7 ± 5.8	86.7 ± 8.2	4.7_9.3	0.001
Follow up 2	79.8 ± 6.9	88.7 ± 4.8	6.1_11.5	0.001
Follow up 3	77.75 ± 4.3	90.1 ± 6.5	4.3_20.3	0.006
Between post-op and final follow up	**4.5 ± 0.7**	**0.3 ± 6**	-15.8_6.1	0.324
Inferior angle				
Intra op	93.8 ± 5.8	95.6 ± 5	-0.1 _ 3.7	0.069
Post-op	93.1 ± 5	94.1± 4.9	-0.5 _ 2.5	0.196
Follow up 1	91.6 ± 5.2	92.8 ±4.2	-0.3 _ 2.5	0.125
Follow up 2	92.03 ± 4	93.4 ± 3.7	-0.5 _ 2.8	0.165
Follow up 3	96 ± 3	91.3 ± 4.2	-10.1 _ 0.8	0.092
Between post-op and final follow up	**1.5 ±4.9**	**0.8 ± 3.5**	-9 _ 7.6	0.838

Figure legend

Figure 1 : Local kyphotic angle

Figure 2: Vertebral body height

Figure 3: Superior and inferior angle

Figure 4: Solid screw

Figure 5: cannulated screw

Figure 6: Changes of local kyphotic angle, vertebral body height and superior and inferior angle during the follow up

Figure 1 : Local kyphotic angle [10]

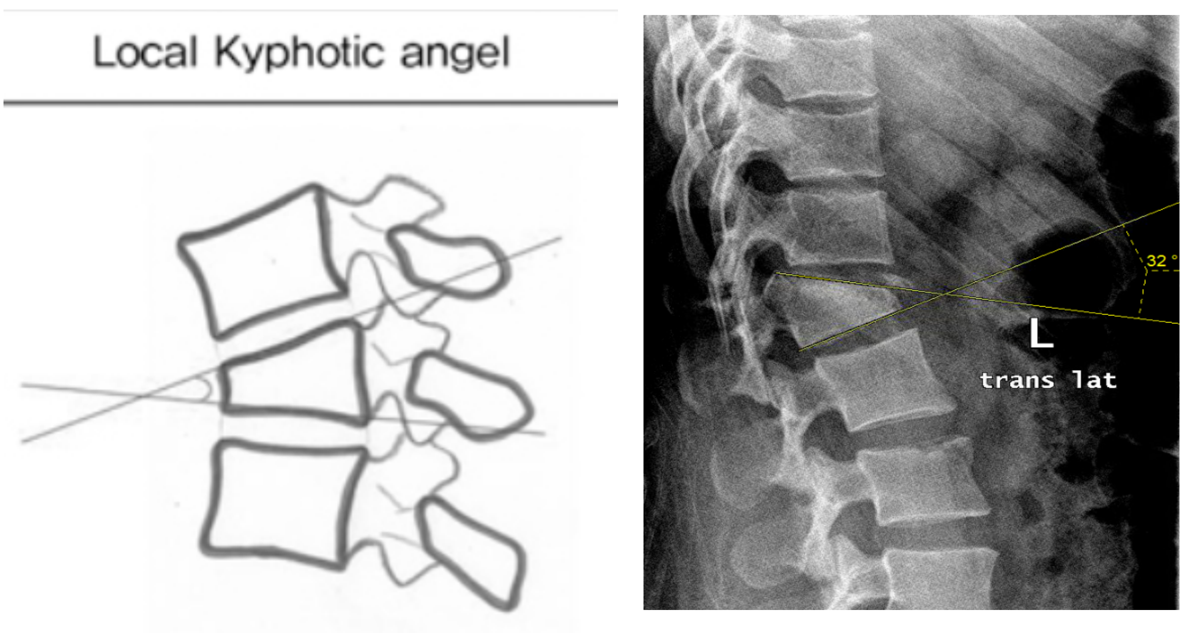
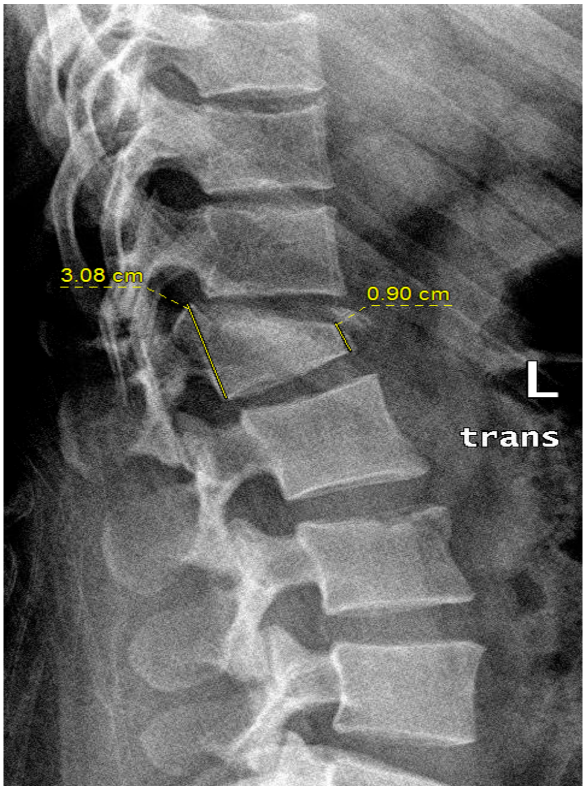


Figure 2: Vertebral body height [6]



Reduction of height was calculated by dividing the anterior wall height over the posterior wall height and then multiply by 100, this give us the percentage of the height of the height of the fractured vertebra and by subtracting it from 100 we get the percentage of reduction in height. So for this case, [(0.90/ 3.08)*100]- 100 = 70.77 % is the reduction in height.

Figure 3: Superior and inferior angle

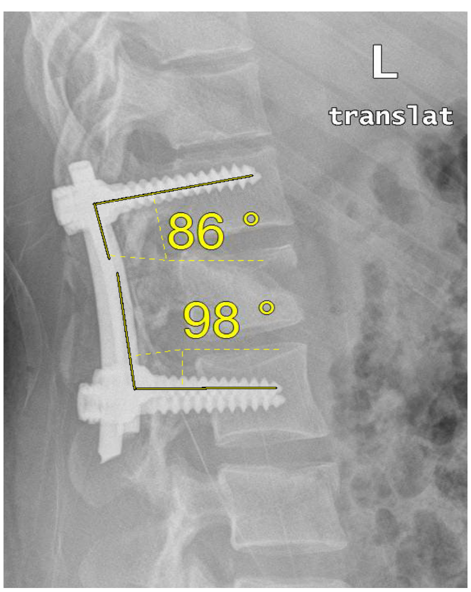
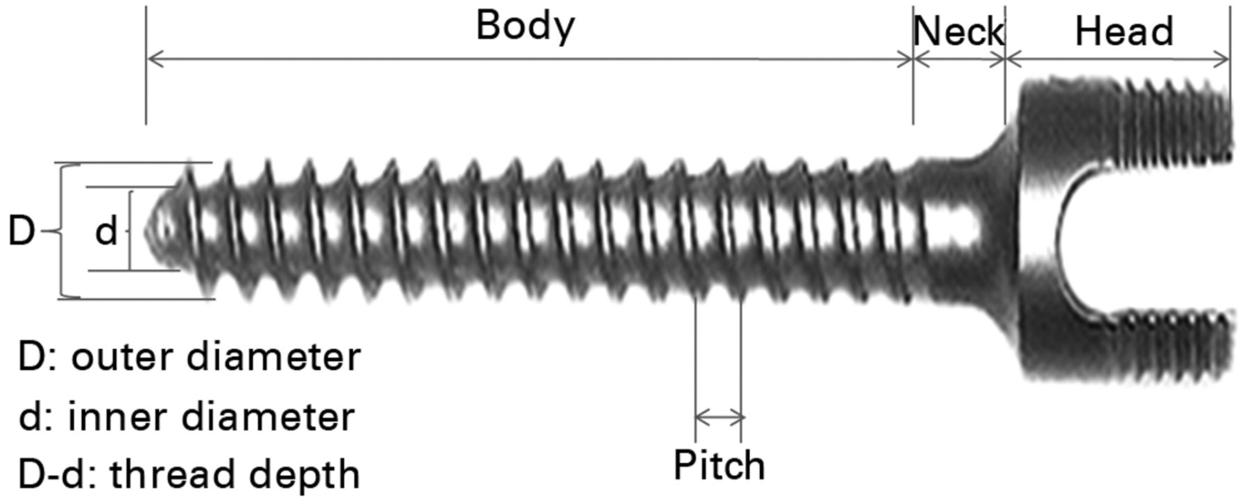


Figure 4: Solid screw [11-12]



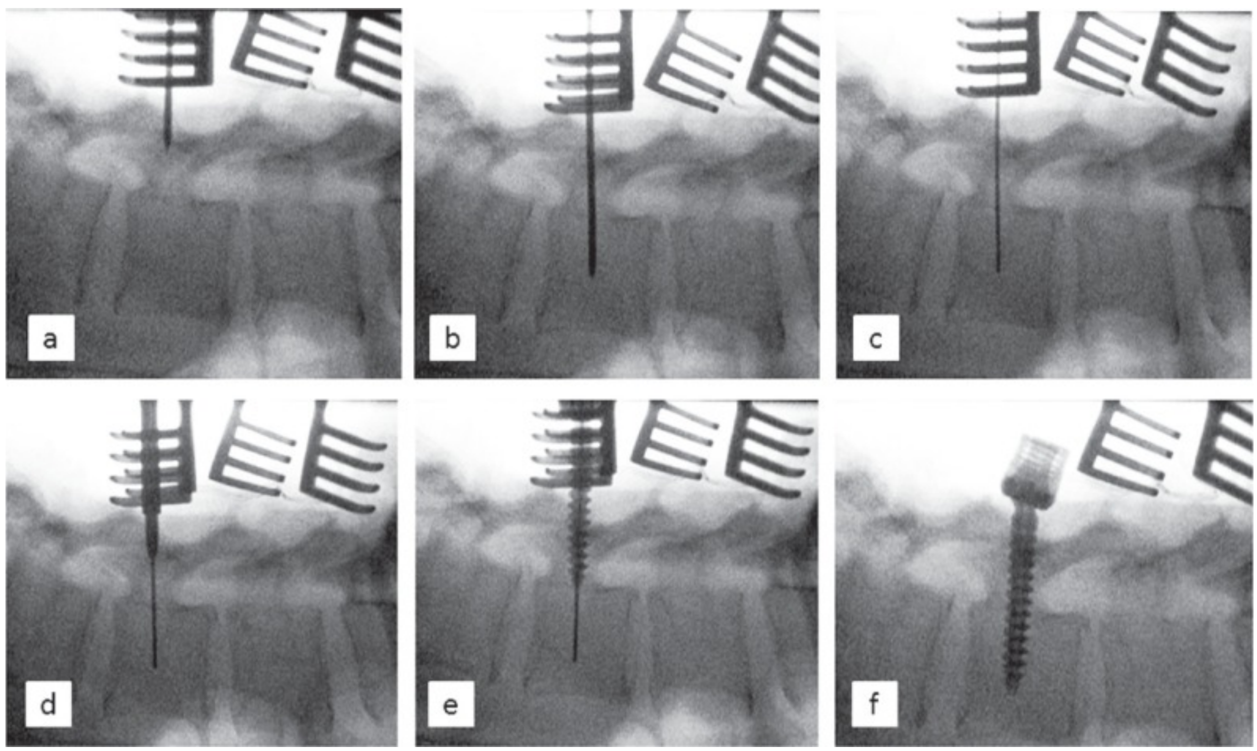


Figure 5: cannulated screw [13]

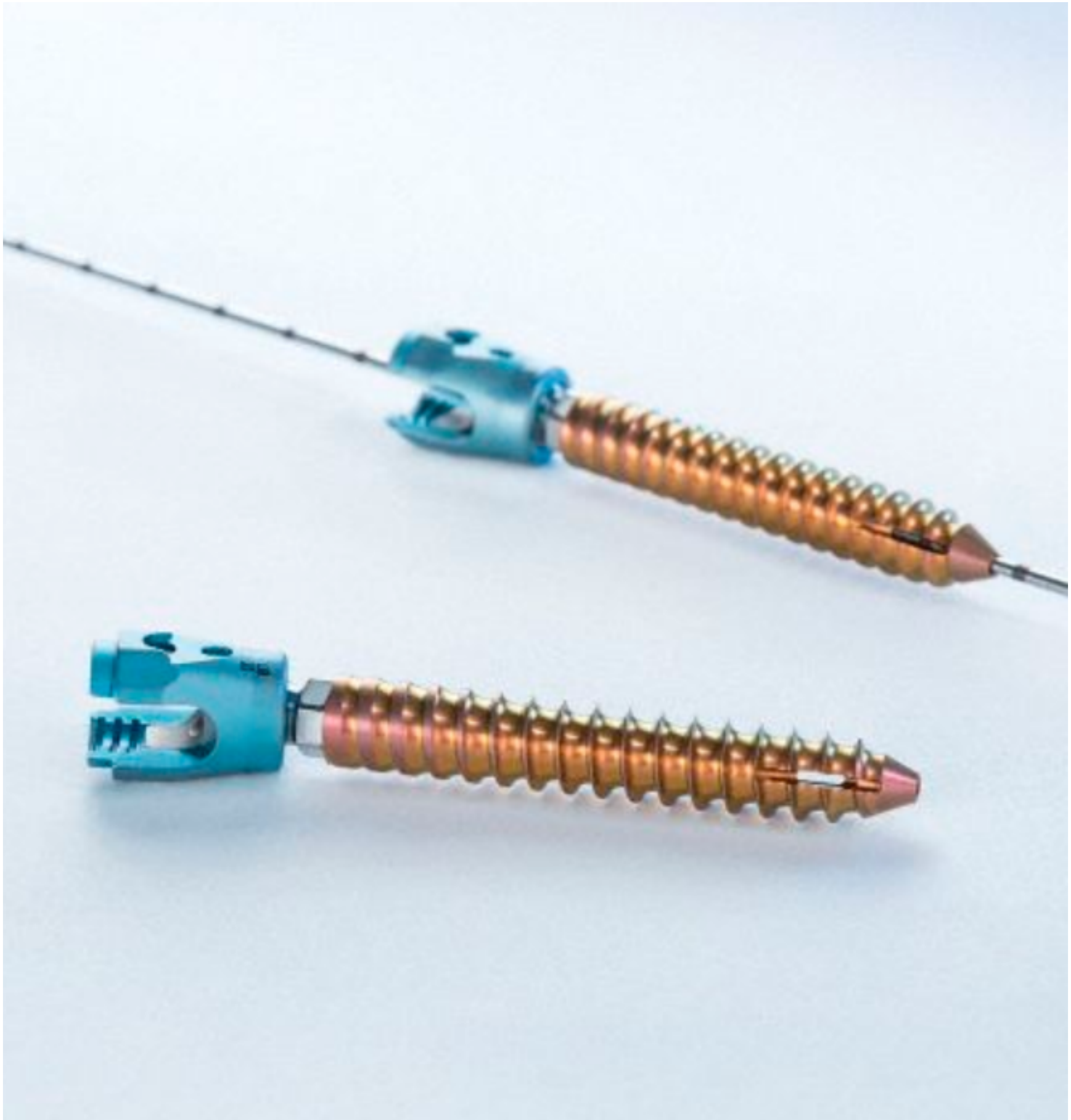
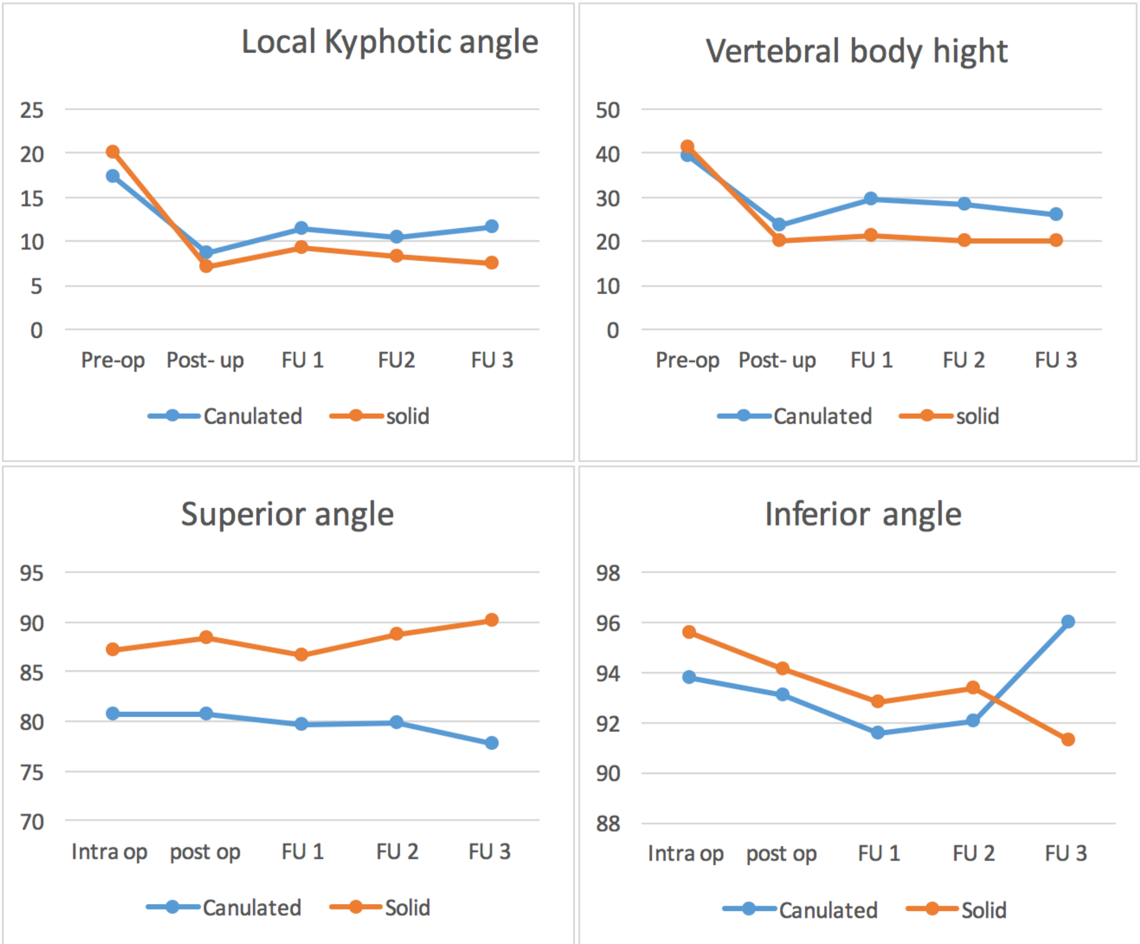


Figure 6: Changes of local kyphotic angle, vertebral body height and superior and inferior angle during the follow up


Local Kyphotic angle
25
20
15
10
5
0
Pre-op
Post- up
FU 1
FU2
FU 3
Canulated
solid
Vertebral body hight
50
40
30
20
10
0
Pre-op
Post- up
FU 1
FU 2
FU 3
Canulated
solid
Superior angle
95
90
85
80
75
70
Intra op
post op
FU 1
FU 2
FU 3
Canulated
Solid
Inferior angle
98
96
94
92
90
88
Intra op
post op
FU 1
FU 2
FU 3
Canulated
Solid