Safe zones of half pin insertion in lumber vertebrae  
Cadaveric study  
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Abstract

Purpose: This experimental study is to know what the safe zones are and angles of half pin insertion in lumber vertebrae, and if there are another new sites for half pin insertion.

Methodology: A cadaver study using two bony and four cadaveric specimens was undertaken to examine the safe sites for half pins insertion in lumber vertebrae. Half pins were inserted in specific demarcated sites.

Results: From our study we suggest that the pedicle of the lumber vertebrae is the safe and strong region for insertion of the half pins with 10 to 40 degrees divergent from the mid line, where the new site of half pin insertion in the vertebral body anterior and at the level of transverse process is safe at angle lies between 50 to 60 degrees from the sagittal plane in L4 and L5.

Conclusion: We concluded that the application of external fixators in the lumber spine is valuable with good safety margins of half pin introduction in both pedicle and vertebral body.

Key words: safe zones, half pins, lumber vertebrae, external fixator

Introduction

In 1977, stabilization of lumber and lower thoracic spine by external fixator had been developed, the system was consists of two levels of schanzs screws inserted into the vertebral bodies through the pedicle holding with external fixator device.(1)

External fixator application in the field of unstable spinal injuries, spinal osteomyelitis proved as effective alternative, as the schanz screws are firmly anchored to the vertebral bodies through the pedicles.(1)

Magrel had proved that external fixators are effective in treatment of unstable spinal injuries, spinal osteomyelitis, as it was superior in comparison with rods in biomechanical stability tests, also it allows for compression, distraction or neutral fixation.(2)

The purpose of this experimental study is to know what are the safe zones and angles of half pin insertion in lumber vertebrae?, and if there are another new sites for half pin insertion?.

Materials and methods

Two bony vertebral column composed of lumber and dorsal spine with ribs attached to the dorsal vertebrae, and four preserved cadaveric specimens were used, , three of them consists of lumber and dorsal spine with coronal cut at L4, show inferior vena cava and abdominal aorta right and left kidneys with their corresponding ureters ,the chest was opened .

The other cadaveric specimen was for demonstration of abdomen and pelvis visceral organs with their blood supply, the whole thoracic and abdominal parts of aorta and inferior vena cava were present with their pelvic branches and tributaries, the nerves of iliohypogastetric,ilioinguinal and femoral nerve were present.( fig.1)

Fig1. Cadaveric specimen shows abdominal aortaand its branches (red colour), inferior vena cava and its tributaries (blue colour), both right and left kidneys, spleen, iliohypogastetric,
ilioinguinal nerves (yellow colour), both ureters (white labelled).

The external fixation set used included 5-mm half pins, 3.2-mm drill bit, and power drill. The bony specimens were examined to show the best sites for half pins insertion.

The data was collected by direct observation of the site of half pin insertion and measurement of the distance between the site of half pin insertion and the important structures.

The bony specimens were examined to show the best sites for half pins insertion, the pedicles of 3rd and 4th lumber vertebrae were demarcated, and the part of the vertebral body anterior to the root of transverse process was examined for half pin insertion. But in 1st and 2nd lumber vertebrae only the pedicle was demarcated for half pin insertion.

To study the possible safe angles and directions of half pin insertion in the pedicles of lumber vertebrae, insertion of 6mm half pins were performed in the demarcated sites on the bony specimens, with divergence from the mid line about 10 to 20 degrees, In addition to insertion of half pins in the vertebral bodies of the 3rd and 4th lumber vertebrae anterior to the root of the transverse process. (Fig.2-A, 2-b)

The cadaveric specimens were dissected to show the important structures, these steps were repeated again in the cadaveric specimens to study the relation of pin insertion sites to the important anatomical structures. (3-A, 3-b, 3-c)
We remove the half pin in the right pedicle and we replace it by stopper half pin to see the position of stopper, then on the left side of the 4th vertebra anterior and at the level of the transverse process another 6mm half pin was inserted in the vertebral body at angle diverted from the mid line about 40 to 50 degrees. (fig.4)

In each step we measure the angles of inserted half pins from the sagittal plane, we did a cross section in the 4th lumber vertebra to see the relation of the inserted half pins to the spinal canal, the spinal canal and the spinal cord were labeled by blue color. (fig.5-A, 5-b)

The cadaveric specimens were dissected to show the transverse lumber arteries which originate from the back of the aorta and pass transverse around the vertebral body and deep to the psoas major muscle then we measure the distance between the body half pin and the lumber artery, also we measure the distance between the body half pin and the abdominal aorta, inferior vena cava and the ureters.(fig 6-A, 6-B, 6-C, 6-D)

Fig.4 , half pin with stopper washer.

A

B

Fig. 5-A , calculation of angle of divergence for both left transpedicular half pin and left body half pin. Fig.5-B, cut section in lumber vertebra no.4 show neuronal canal marked in blue and the tract of both pedicular and body half pins.
Both kidneys are anatomically located at the level of L1 to L3, so we limit the application of the half pin in the new site only for lumber vertebra number 4 and 5. (Fig. 7)

We finally assembled external fixator composed of two half pins inserted into the pedicle of the 3rd lumber vertebra and connected to each other birch of Ilizarov. (Fig. 8)

Fig. 7, the location of RT. And LT. Kidney in front of lumber vertebrae.

Fig. 8, illizarov construct for one level stabilization.

Results

In regard to the site of insertion and the direction of half pin insertion, it was found that the pedicles of the all lumber vertebrae are safe regions for insertion of the half pins within 10 to 40 degrees divergent angle from the mid line.

On the other hand the new site of half pin insertion in the vertebral body anterior and at the level of transverse process is safe at angle lies between 50 to 60 degrees from the sagittal plan in both 4th and 5th lumber vertebrae where the 1st, 2nd and 3rd vertebrae not amenable for this new site of half pin insertion as there is high risk of injury of both kidneys.

At the level of both 4th and 5th lumber vertebrae, the lumber arteries on both right and left side are located 0.5 to 1cm inferior to the transverse process of corresponding vertebrae, while the ureters on both sides are about 4.5 to cm anterior to the new site of half pin insertion in L4 and L5, where the aorta and inferior vena cava are about 3 to 4 cm away from the new site of half pin insertion in the vertebral body. (Fig. 6-A, 6-B, 6-C, 6-E)

Discussion

Since 1977 Friedrich P. Magerl had developed his external fixator device for stabilization of the lumber and dorsal vertebrae in the field of spinal trauma and infection. The system was consists of two pairs of Schanz screws and an adjustable external fixation device. (1)

Biomechanically, external fixator showed more stability than rod distraction system and fixation with plating as the schanz screws can securely be
anchored through the pedicles into the vertebral body. (1, 2)
In February 2006, Fenichel had published a case report about the use of External Fixation for the Treatment of Osteomyelitis of the D2 vertebra with an epidural abscess caused by Actinomyces israelii that spread from the lung and was treated by decompression and external fixation. (3)
In 1999, a study was published as experimental external fixation combined with discectomy in management of scoliosis in young rabbits, the results of this study suggest the versatility of the external fixator that allows derotation which offers a feasible method of managing scoliosis in the human adolescent. (4)
Juhanisoini, et al. had published the usage of external transpedicular fixation to the lower lumber spine in prospective study on 42 patients with chronic low back pain with instability of the lumber segment. (2)
Anatomically, the lumber pedicles are directed backward from the upper part of the body, it represent a prominent structure that suitable for Schanz screw fixation. (5)
In regard to the previously anatomical, clinical and experimental studies it was suggested that the pedicle is the safest and the strongest site for half pin insertion in the lumber vertebrae.
In this current study authors prefer the pedicle as the first site to be chosen for half pin insertion in all lumber vertebrae.
Magerl concluded that the Schanz screws should lie parallel to the end-plates with an inclination toward the sagittal plane of about 10° at the thoracolumbar junction, increasing up to 15°-20° at L5. The larger size of the pedicles in the lower lumbar area offers more margin of safety for placement of the screws. (1)
In this experimental study the authors went in the same line with the study done by Magerl and they offer more safe zone of angulation up to 40 degrees in the pedicular half pin and authors suggest another new site of pin insertion in the vertebral body anterior and at level of transverse process with safe zone lies between 50 to 60 degrees divergent from the center which is represented by lumber posterior spinous process, which is preferable in lumber vertebrae number 4 and 5.
To the authors knowledge the new site for half pin insertion in the vertebral body have not been discussed in any literature or experimental study.
In literature, the transverse process in in the 3rd lumber vertebrae is longer than in the 2nd, 4th and 5th lumber vertebrae.(5, 6), also the abdominal aorta begins at the lower level of T12 then it descend downward till the level of L4 as it terminated by right and left common iliac arteries. (5)
Lumber segmental arteries originate from the posterior surface of the abdominal aorta, they are four pairs and are very close to the vertebral bodies, the right ones are longer than the left. (5)
In this current study the authors had measured the distance between the half pin in new site and the nearby vital structures the authors found that the lumber segmental arteries lies 0.5 to 1cm inferior to the transverse process of corresponding vertebrae, the distance between abdominal aorta, inferior vena cava and ureters also measured, and they considered this new site as safe site for half pin insertion in lumber vertebrae number 4 and 5, but the authors concluded that this new site of half pin insertion is dangerous for lumber vertebrae number 1, 2 and 3 as there was possibility of injury of both kidneys.
Literature on safe zones and angulations of half pin insertion either in the pedicle or in the new site we suggest are limited, so we suggest that this study will open the door for further precise studies and more superior experimental tests as there were limitation of this current study which is the small number of cadaveric specimens and the way of preservation.

**Conclusion**
From this study we concluded that the application of external fixators in the lumber spine is valuable with good safety margins of half pin introduction in both pedicle and vertebral body.
This study for further evaluation by further investigations and by clinical application

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