# Investigation of vertebral level termination of spinal cord by ultrasonography and dissection techniques in human fetuses

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*An investigation was performed on 41 fetuses obtained from the Konya Maternity Hospital having between 55 to 230 mm CRL and kept 10% formaldehyde in order to find out the vertebral level terminations of spinal cord by ultrasonography and dissection techniques. Vertebral level termination of spinal cord was determined to reach to the L3 vertebral level in the fetuses which have 230 mm CRL. When the findings of this study was compared previous reports. Vertebral level termination of spinal cord of Turkish fetuses were observed to be different than those of Southern Indian and Saudi Arabians' and similar to Northern Indian and Westerns'. The ultrasonography findings are found to be in agrément with dissection results for the determinations of vertebral level termination of spinal cord and abnormalities. It was concluded that ultrasonography might be routinly used in children in order to provide an early diagnosis for spinal dysraphism and abnormalities of spinal cord without radiation and sedation. [Turk J Med Res 1995; 13(1): 1-7]*

Key Words: Spinal cord termination level, Ultrasonography, Dissection techniques

The medulla spinalis usually terminates at discus intervertebralis level through L1 and L2 vertebrae in adults (1-6). This level is lower in women and the black race (7,8), but also known to be between Th12 and L3 vertebrae (5,9).

It is asserted that the medulla spinalis termination level in infants is not lower than the discus between L2-L3 vertebrae (10), but reaches an adult's level (11,12). It is stated to be normal that the conus medullars stands at L2-L3 or at a higher vertebral level in any age (9). The medulla spinalis vertebral termination level in fetuses changes through the pregnancy period (5,8,13,14). The rates of growth of medulla spinalis and columna are equivalent up to 30 mm CRL. In fetuses, the segments of medulla spinalis and of columna vertebralis are equivalent to each other; the rate and time of growth is changing after 30 mm CRL (8).

The primitive mesoderm starts growing before neurectoderm (8). As a result of this, the columna vertebralis displaces towards caudale and conus medullaris to cranial (5,8,13). A faster growth of the columna vertebralis causes the conus medullaris and medulla spinalis segments to stay above and thus it leads the spinal nerve roots in the vertebral canal to gain an oblique shape, and finally it results with the appearance of cauda equina in the lumbo-sacral region (3,6,13).

Kunitoma (8), Streeter (8) and Barry (15) in the USA, Barson (16) in England, Hawass and friends (17) in Saudi Arabia, Jit and Charnalia (10) in Norther India, Rao (12) and Vettivel (8) in Southern India have investigated the medulla spinalis vertebral termination level in fetuses and reported different results for fetuses of the some CRL. It is stated that the medulla spinalis vertebral termination levels of the South Indian and Saudi Arabian fetuses end at a higher level than those of the North Indian and Westen fetuses' (8,10,12,15-17).

In this study, the medulla spinalis vertebral termination levels of fetuses of 55 mm-230 mm of CRL size were investigated with ultrasonography and dissection methods. The dissection and ultrasonography (US) findings were compared with the literature.

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## MATERIALS AND METHODS

In this study, 25 male and 16 female fetuses preserved in 10% formaldehyde were used. The fetuses were provided by the Konya Maternity Hospi-

tal. Their ages were determined according to their CRL measures. CRL measures were between 55 mm and 230 mm.

In the US examination, a TOSHIBA SAL 77B US total was used. It was looked through the posterior with a 7.5 MHz linear probe. By smearing a jelly to the fetuses lumbo-sacral region, cross-sectional view of spinal canal on the sagittal plane was made. First, the coccyx was determined. After the hypoechogeneous bone sight of the coccyx was determined, determination of the levels of the vertebrae was made following the S5-S1, L5-L1 arrangement by counting the hypoechogeneous vertebral bodies as from the hyperecogen disk interval next to coccyx. The lower tip, where the thinning of the dural sac ends and where the dural interval begins straight to continue, was accepted to be the medulla spinalis terminating point. A cross section sight of each fetus was pictured with a printer. Events with a local widening in the medulla spinalis, a change and disorder in the eco, were evaluated with US as anomaly.

After US examination, fetuses were dissected. By removing the skin and the soft tissues, columna vertebralis was brought out from the back side. The Th12 vertebrae joining with the 12th costa, and the lumbal and sacral vertebrae were determined respectively. By removing the archer of the lumbal and sacral vertebrae, the duramater was found. Holding the duramater with a pliers, a small incision was applied by separating it from the medulla spinalis. Next, the duramater spinalis was removed without cutting the medulla spinalis and the spinal nerves. After the cauda equina was brought out, the conus medullaris and filum terminale were observed by separating the spinal nerves from each other. The level of vertebrae where conus medullaris ends, was established according to the vertebrae which were determined from top to bottom.

The correctness of the coccyx in the dissection that is taken as the origin in the US, was checked by making a sagittal cross section to the fetuses through the line where the medulla spinalis passes from the posterior midline.

The grouping measures of Vettivel (8) were taken as essential for grouping. According to this, the groups of fetuses were as follows; II.group 46-70 mm CRL; III.group 71-95 mm CRL; IV.group 96-110 mm CRL; V.group 111-140 mm CRL; VI.group 141-160 mm CRL; and VII.group 161-230 mm CRL. Fetuses smaller than 45 mm CRL in the I.group and newborns in the VI11.group were not included in the study.

## RESULTS

The CRL, sex, USG and dissection findings were shown in Table 1.

Th12 vertebra and L1 vertebra could not be determined in the US examination. Looking to the canalis vertebralis from the posterior at a sagittal and transvers plane, arcus vertebralis at the back, then the posterior dura, central canal and the hypoechogeneous band of the dura were pictured respectively. At cross sectional plane, the column of the vertebral body of lowest level was pictured. The spinal canal was pictured being highly hypoecogeneous with a thin echogeneous medulla spinalis in its middle. In the lower tip, the medulla spinalis ending and the canal width ending were not confirming. Tip of the medullary

**Table** 1. The CRL, sex, ultrasound and dissectic findings

| No | CRL | Sex | Ultrasound | Dissection |
|---|---|---|---|---|
| Group II | | | | |
| 1 | 55 | M | | S5 |
| 2 | 65 | M | – | S4 |
| Group III | | | | |
| 3 | 80 | M | – | S3 |
| 4 | 90 | M | -Anomaly | Co3 Anomaly |
| 5 | 95 | M | S1 | S1 |
| 6 | 95 | M | -Anomaly | S3 Anomaly |
| Group IV | | | | |
| 7 | 105 | F | -Anomaly | S2 Anomaly |
| 8 | 105 | M | S1 | S1 |
| 9 | 105 | M | S1 | L5 |
| 10 | 105 | M | S1 | S1 |
| 11 | 110 | M | S1 | .S1 |
| Group V | | | | |
| 12 | 130 | M | S2-3 Anomaly | S2 Anomaly |
| 13 | 130 | F | S1 | L5 |
| 14 | 135 | M | L5 | L5 |
| 15 | 135 | F | L5 | L5 |
| 16 | 135 | F | L5 | L4 |
| 17 | 140 | M | L5 | L4 |
| 18 | 140 | M | L5 | L4 |
| Group VI | | | | |
| 19 | 145 | M | L4-5 | L4 |
| 20 | 145 | M | L4-5 | L4 |
| 21 | 160 | F | L4-5 | L4 |
| 22 | 160 | M | L4 | L4 |
| 23 | 160 | F | L4-5 | L4 |
| 24 | 160 | F | L4 | L4 |
| Group VII | | | | |
| 25 | 165 | M | L4-5 | L4 |
| 26 | 170 | M | L4 | L4 |
| 27 | 170 | F | L4-5 | L4 |
| 28 | 170 | M | L4 | L4 |
| 29 | 175 | M | L4 | L4 |
| 30 | 180 | F | L4 | L4 |
| 31 | 180 | M | L4 | L4 |
| 32 | 190 | F | L4 | L4 |
| 33 | 190 | M | L4 | L3-4 |
| 34 | 190 | F | L4 | L3-4 |
| 35 | 190 | F | L4 | L4 |
| 36 | 200 | F | L4 | L4 |
| 37 | 200 | F | L4 | L4 |
| 38 | 210 | F | S2 Anomaly | S2 Anomaly |
| 39 | 210 | M | L4 | L3 |
| 40 | 230 | M | L4 | L3 |
| 41 | 230 | M | L4 | L3 |


Figure 1A.The lumbosacral region sagittal US cross-section of a fetus of 230 mm CRL

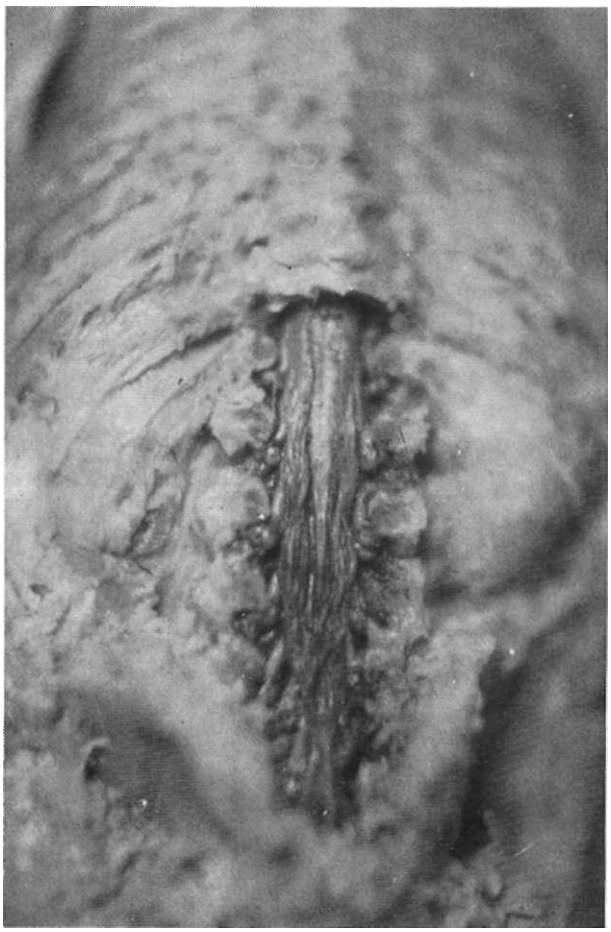

Figure IB.The medullary cone and cauda equina of the same fetus after dissection. The medullary cone gradually changes into filum terminale (Event No:40)

cone could not be pictured sufficiently. The dural sac width ending level was taken to be essential. Coccyx was pictured as curled hypoechogene, and the disk interval as wide, oval hyperechogene. The other bodies were seen as thin hyperecogen in the middle, and as gradually ending hypoecogeneous structures in the sides (Figure 1 A,B). Accepting the disk interval after coccyx as the sacrum-coccyx joining, vertebral bodies were counted from bottom to top. In order to investigate the correctness of the vertebral termination level fixation made with US, fetuses were dissected and the position of the medulla spinalis in the sagittal plane was compared with the US. Medulla spinalis vertebral Termination level of determinations made with USG were correct in all events (Figure 2 A,B). The medulla spinalis vertebral termination level was lower in anomalous events with respect to other events being in the same group. Three fetuses smaller than 80 mm CRL could not be pictured with US. In these fetuses, although spinal canal could be seen, the vertebral level termination of the medullary cone could not be determined with US (Figure 3).

In five events, cord anomalies were diagnosed with US (Figure 4 A,B,C). The dissection results showed that these 5 diagnoses were correct (100%). The medulla spinalis vertebral termination level of two male fetuses of 55-70 mm CRL (ll) could not be established with US. But in the dissection, these levels


Figure 2A.In the lumbosacral region sagittal cross-section of a fetus of 190 mm CRL, the vertebral bodies are hypoechogenous and the disk intervals are hyperechogenous. The medulla spinalis vertebral level of termination is L4.

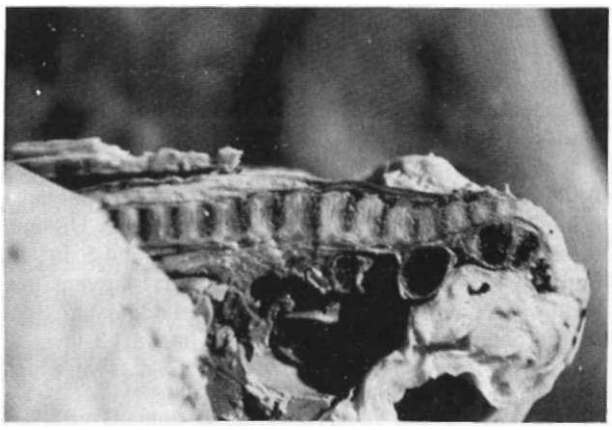

Figure 2B.In the dissection of the same event, the medulla spinalis vertebral level of termination is between L3-4 in the sagittal cross-section (Event No: 33).

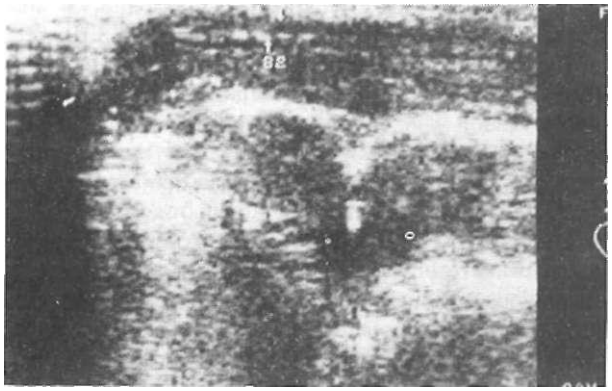

Figure 3. In the lumbosacral region US cross-section of an E fetus of 65 mm CRL, the vertebral structures are not clear (Event No: 7).


Figure 4A.Anomaly in a male fetus of 210 mm CRL. In the US sagittal cross section, the medulla spinalis is wider, disorderly and hyperechogeneous at L4-5 vertebral level. The medulla spinalis terminates at S2 level.

were established to be S5 for a fetus of 55 mm CRL, and as S4 for a fetus of 65 mm CRL (Table 1).

Four fetuses of 71-95 mm CRL (III) were examined. Among these, the medullary cone termination level of one male fetus of 80 mm CRL could not be determined. In 2 fetuses anomalies were determined through US and dissection. In one fetus, the termination level of medulla spinalis was fixed as S1 by US which is confirmed by dissection (Table 1).

In one of five fetuses of 96-110 mm CRL (IV), anomaly was determined in US and dissection. In the other 4 fetuses the medulla spinalis termination level was S1 in US. In the dissection, this level was S1 in 3 fetuses and L5 in one fetus (Table 1).

In one out of 7 fetuses of 111-140 mm CRL (V), an anomaly was established in US and dissection. In one event, the medulla spinalis terminated at S1 level with US and L5 level with dissection; L5 level with US and dissection in two events; L5 level with US and L4 level with dissection in three events (Table 1).

When 6 fetuses of 141-160 mm CRL (VI) were examined, the medulla spinalis vertebral termination level was to be L4-5 with US, L4 with dissection in 4 events; and L4 with US and dissection in 2 events (Table 1).

In the group of 165-230 mm CRL, 17 fetuses were examined. Anomaly was determined through US and dissection in one fetus of 210 mm CRL (Figure 3 A,B). It was observed that in this event the medulla spinalis vertebral termination level was S2 in US and dissection. In two events this level was L4-5 in US and L4 in dissection. In the remaining 14 event this level was L4 in US. The dissection findings in 8 of them confirmed with US; 4 of them had a L3 level. 2 events of 190 mm CRL showed an L3-4 level which was different from the US findings (Table 1).

In all of the anomalous cases, the medulla spinalis termination level was determined to be lower than the levels of the fetuses in the same group (Table 1).

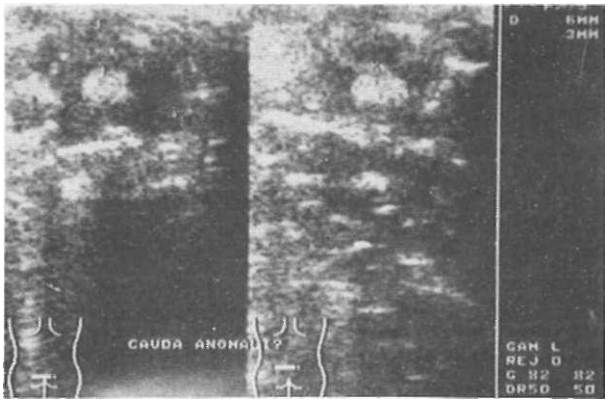


Figure 4B. While in the transvers US cross-section, the anomalous region is seen to be wide and hyperechogeneous, in the transvers US cross-section taken from a higher level, the medulla spinalis is seen to be hypoechogeneous and at a normal thickness.

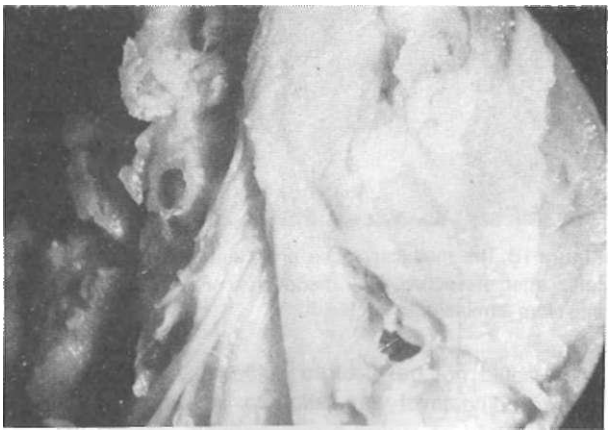

Figure 4C.The anomalous region pictured by the steieomicroscope in the dissection is wider than the normal, and the medulla spinalis terminates at the level of S2 vertebra.X12 (Event No: 38).

It was observed that in the conus medullaris-filum terminate boundary, the filum terminate graudally becomes narrower and continues this for a while. In all events, it was seen that the point, where the thinning of filum terminate ends and begins to continue at the same thickness, is at the same vertebral level together with the region which was established in the US to be the conus medullaris termination (Figure 1A.B).

## DISCUSSION

The medulla spinalis termination levels of fetuses smaller than 40 mm CRL are in the coccygeal region (8). The medulla spinalis termination (MST) of South Indian fetuses of 40-45 mm CRL is reported to be at the S5 vertebra level (8,12). While the MST level in fetuses of 46-70 mm CRL is in the coccygeal region in American (8,15) and English (16) studies, in South Indian (8,12) and Saudi Arabian (17) fetuses, it is at the S4-S2 vertebra level. Of 71-95 mm CRL fetuses, the MST level of South Indian (8,12) fetuses was S1, and in Saudi Arabian (17) fetuses. In fetuses of this age, the level is to be S1 in the Michigan material (15) in America and to be S3 in English (16) fetuses. The MST level of the fetuses in this group were determined to be S5 at 55 mm CRL, S4 at 65 mm CRL and S3 vertebra level at 80 mm CRL in the study. An anomaly was observed in a fetus of 90 mm CRL, and the medulla spinalis ended in the coccygeal region. It should be remembered that there may be spinal cord anomaly if in the US the medulla spinalis vertebral termination level should be found to be at a lower degree with respect to the same CRL group.

White the MST level in fetuses of 96-110 mm CRL is to be at S2 in Northern India (10), S1 in England (16), and at L5 vertebra level in Southern India (8,12) and Michigan material (15), it was informed that it reached the L3 vertebra level in Saudi Arabian (17) fetuses.

In fetuses of this CRL, the m.s.v.t. level was S1 in two fetuses and L5 in one fetus. In two fetuses of this group, anomaly was determined.

The MST levels of fetuses of 111-140 mm CRL were at L4 in Southern India (8,12), Saudi Arabia (17) and England (16), L4-L5 in the Michigan material (14) and L5 in Northern India. It was observed that in fetuses of this length, the medulla spinalis terminates at various levels from the S1 to L4 vertebrae.

The MST of 141-160 mm CRL fetuses were at L3 vertebra level in Saudi Arabia (17), at L4 in Southern India (8,12), Michigan Material (15) and England (16), and at L5 vertebra level in Northern India (10). In our study, the MST was determined to be at L4 vertebra level in all 141-160 mm CR fetuses.

In fetuses higher than 160 mm CRL, the MST levels were at L3 in America (15), England (16) and Northern India (10), and L2 in Saudi Arabia (17) and Southern India (8,12). In this study, the MST level of fetuses higher than 160 mm CRL was at between L4 and L3, and in 210 mm CRL fetuses, the vertebra level was L3.

According to this study, the MST level of Turkish fetuses is different than those of South Indian and Saudi Arabian's but it shows some similarities with North Indian and Western fetuses' MST level.

In the US investigation, the duramater is seen as a hyperechogeneous line at the front and at the back (18-20). The canalis centralis is seen as hyperechogeneous and the medulla spinalis as hypoechogeneous (21-23). The medullary cone gradually gets thinner and extends towards sacrum as filum terminate. In normal children, the beginning of filum terminate may be seen as hypoechogeneous between the hyperechogeneous structures of the cauda equina (24). The region where the medullary cone changes to filum terminate could not be distinguished exactly with US. The dural sac in the cauda equina gradually gets narrower with respect to the cauda equina shape (18). In our study, the level where the dural sac terminates its gradual thinning, was accepted to be the lower tip of the medulla spinalis. For that reason, a difference appears between the lower tips of the conus medullaris determined with US and dissection respectively. The US and dissection findings of fetuses up to 135 mm CRL are confirming more with each other (Figure 5). As the fetal age increases, the medulla spinalis moves towards higher vertebral levels with respect to the columna vertebralis (5,6,8,13,14).

The determination of the lower tip of the medullary cone with US is seen at a lower level due cauda equina.

It is possible to diagnose the anomalies which arise in the medulla spinalis with US (25,26). The echo of central canal is not seen in the region of anomaly, the normal homogeneous hypoechogene echo structure gains a more hyperechogeneous or hypoechogeneous feature (27). In our study, 5 anomaly diagnoses were made with US and the US diagnosis was confirmed by the dissection. It is remarkable that anomalous cases occur more frequently in early fetal ages (Table 1). Since in cases with anomally the displacement of the medulla spinalis due to anomaly towards a higher point with respect to the columna vertebralis is avoided, the vertebral termination level takes place at a lower level with respect to the fetal age (Table 1).

The US can be used routinely and safely both in the determination of the medulla spinalis vertebral termination level and in the early diagnosis of the spinal dysraphism and medulla spinalis anomalies it.

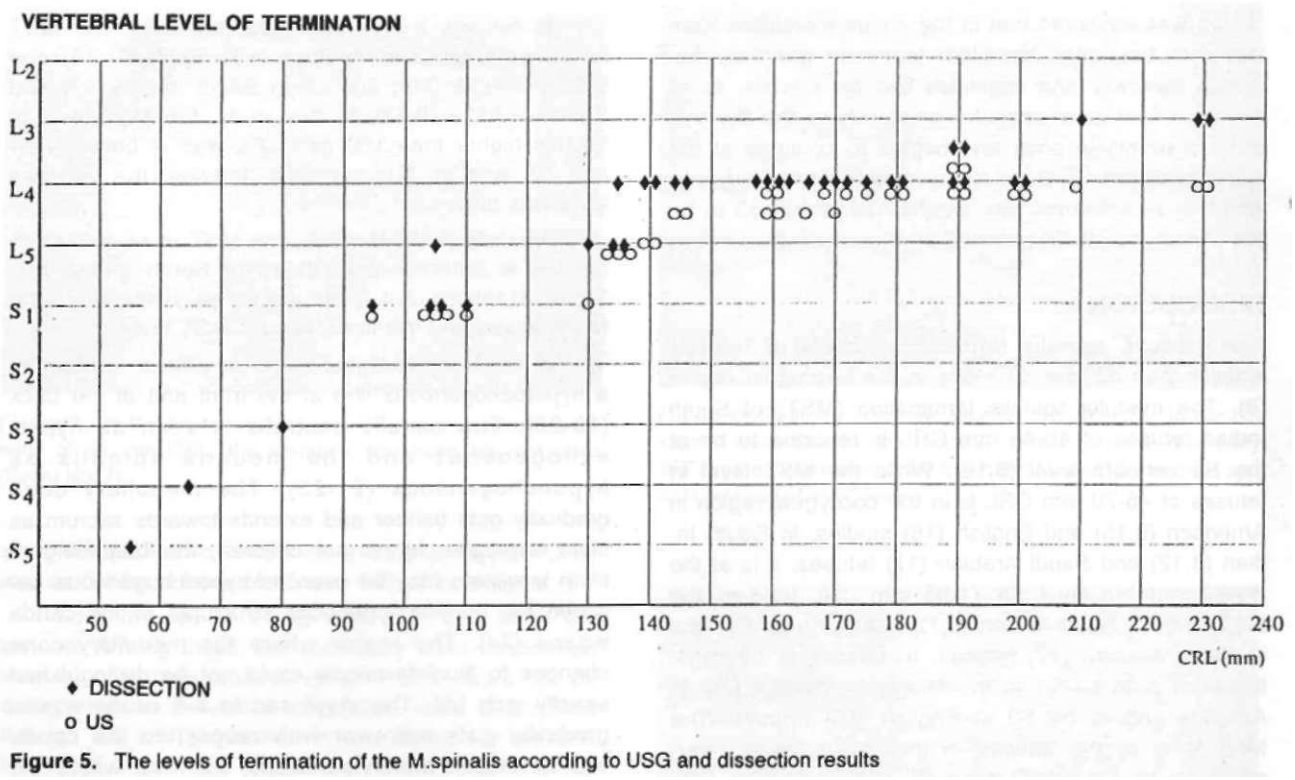


**Figure 5.** The levels of termination of the M.spinalis according to USG and dissection results

**insan rötuşlarında medulla spinalis vertebral sonlanma seviyelerinin ultrasonografi ve diseksiyon yöntemleriyle araştırılması**

*Konya doğumevinden sağlanan ve %10 formaldehitte muhafaza edilen, CRL'si 55 mm-230 mm arasında değişen 41 fötusun medulla spinalis vertebral sonlanma seviyesi ultrasonografi ve diseksiyon yöntemleriyle araştırıldı. Çalışmada 230 mm CRL'ye sahip fötusların medulla spinalis vertebral sonlanma seviyesinin L3 vertebra seviyesine ulaştığı tespit edildi. Çalışmanın verileri literatür verilerine karşılaştırıldığında Türk fötuslarının medulla spinalis vertebral sonlanma seviyelerinin Güney Hindistan ve Suudi Arabistan fötuslarından farklı olduğu, Kuzey Hindistan ve Batılı fötuslar ile benzerlik gösterdiği gözlendi. Medulla spinalis vertebral sonlanma seviyesi ve anomali tespiti bakımından ultrasonografi bulgularının diseksiyon bulguları ile uyumlu olduğu görüldü. Ultrasonografi çocuklarda; spinal disraphism ve medulla spinalis anomalilerinin erken tanısında radyasyon riski taşımaması ve sedasyona gerek olmadığından rutin olarak kullanılabilir.*

*[Turk JMedRes 1995; 13(1): 1-7]*

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