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## of Medical Research: H

# Orthopedic & Musculoskeletal System

Degenerative Lumbar Canal

Minimally Invasive Flat Foot Alingment

Highlights

Fixation of Tibial Spine Fracture

Morphological and Histological Changes

**Discovering Thoughts, Inventing Future**

VOLUME 20 ISSUE 4 VERSION 1.0

Global Journal of Medical Research: H
Orthopedic and Musculoskeletal System

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# Minimally Invasive Flat Foot Alingment: A New Method

By Rodrigo Schroll Astolfi, Sarah Araújo Lima, Rayanne Carneiro Torres de Novaes, Henrique Cesar Temoteo Ribeiro, Alexandre Leme Godoy Santos & José Alberto Dias Leite

*Abstract-* Medializing calcaneal osteotomy is one of the most common procedures in flat foot alignment. Recently it has been done percutaneously with several different techniques, most of them made in lateral position. Our paper aims to describe the minimally invasive calcaneal medializing osteotomy in ventral position, easier for x-ray control, faster to patient positioning with technical tips to more precise bone cut and reduction. Between April 2019 and September 2019, 10 patients were operated using this technique. Patients in ventral position, sciatic nerve block, percutaneous Achilles lengthening, transcutaneous k-wire passage for drill cut control. Straight calcaneal cut, reduction in medial and plantar position and control both in lateral and axil views. 15 patients were operated using this technique. 67% were woman. Median age were 38.9 years and median BMI was 23.5.

*Keywords: flat foot, minimally invasive, hindfoot, medializing calcaneal, percutaneous.*

*GJMR-H Classification: NLMC Code: WE 168*


*Strictly as per the compliance and regulations of:*

# Minimally Invasive Flat Foot Alingment: A New Method

Rodrigo Schroll Astolfi [α], Sarah Araújo Lima [σ], Rayanne Carneiro Torres de Novaes [ρ], Henrique Cesar Temoteo Ribeiro [ω], Alexandre Leme Godoy Santos [¥] & José Alberto Dias Leite [§]

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All patients were able to bear full weight immediately. No cases of non-consolidation were observed, and consolidation occurred in all patients by 6 weeks as pain reduced, and initial signs of calcification could be detected in x-ray.

This is a descriptive paper with technical tips for percutaneous flat foot correction. Using these methods, the surgery becomes faster as patient position is the same for nerve block and for surgery, easier for calcaneal positioning in plantar and medial position, safer for drill use with the k-wire protection and easier for trans-operatively x-ray control. We also show some of the results before doing these modifications.

*Keywords: flat foot, minimally invasive, hindfoot, medializing calcaneal, percutaneous.*

## I. Introduction

Calcaneal osteotomy is a well-established surgery for flexible flat foot (1, 2). Many methods are possible and one of the most used is the calcaneal medial translation popularized by Kouktsogiannis (1), commonly associated with tendon transfer and spring ligament reconstruction. (1,3,4,5).

Calcaneal medialization was usually made to favor the tendon transferred once the initial understanding was that the progressive flat foot in adults was secondarily to a tibialis posterior insufficiency. As tibialis posterior was the initial cause of the disease, it's substitution by a healthy despite weaker tendon was necessary. (1,4,5,6,7,8,9).

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Some recent evidence has shown that in many cases, the disease starts as a ligamental insufficiency and the healthy tibialis posterior reacts trying to compensate and in a later pathology moment degenerate. (1,5,8,10)

This new understanding led to surgeries to address ligament reconstruction preserving tibialis posterior (1,3,5,6,8) or isolated calcaneal osteotomies to give a better leaver arm for the tendon function (11,12,13). Minimally invasive calcaneal osteotomy is one possible technique for flat foot correction with many possible advantages are earlier weight bearing and earlier consolidation. (11,12,13)

Most descriptions about this technique are made with the patient in lateral position with a lateral approach in a similar fashion as open techniques. (11,12,13). This paper describes the minimally invasive technique made by one lateral or medial approach in a ventral position and our initial results.

## II. Methods

Between April 2019 and September 2019, 10 patients were operated using this technique. Surgery is performed in ventral position under a sciatic nerve block. Consent was obtained and protocol was approved by local and national ethical committees. All patients have a percutaneous Achilles stretching. One k-wire is inserted transcutaneously at the desired site for the osteotomy (figure 1). Lateral incision of about 5 mm large is made at the center of calcaneus.

A percutaneous periosteal elevator is inserted and only the line for the burr passage is dissected to allow minimal soft tissue disruption. The 2,5/20 mm Shannon burr is used. One dorsal to plantar direct and straight cut is made with the fluoroscopic visualization and the use of the k-wire as a guide for the cut. At this point an instrument can be inserted at the portal to leverage the fragment to in a plantar and medial direction or a Steinman 3.0 wire is passed near the Achilles insertion were a stronger bone is expected.

Lateral and axial views are easily performed in this position to check the ideal position for calcaneus and screws (figure 2).

Full weight bearing is permitted immediately. In 6 weeks strengthening exercises are initiated.

15 patients were operated using this technique. 67% were woman. Median age were 38.9 years and median BMI was 23.5.

## III. Results

All patients were able to bear full weight immediately. More swelling and pain was seen in the younger patients.

No cases of non-consolidation were observed, and consolidation occurred in all patients by 6 weeks as pain reduced, and initial signs of calcification could be detected in x-ray.

No cases of infection, skin problems, nerve or vascular damage were detected, but two cases of proximal migration of distal fragment occurred before we adopted the Achilles lengthening in all patients.

## IV. Discussion

Painful flat foot is one of the most common orthopedics lesions in the elderly population, possibly because of progressive ligament insufficiency (8,14). Once a valgus deformity is formed, non-conservative treatment has proved to correct definitively (8,14). Bilateral flat foot has been associated with anterior knee pain, lumbar spine pain, besides hindfoot and ankle arthritis (15,16).

Once the valgus alignment is present the deformity tends to evolve (6,14,16,17,18). As population goes older because of the longer life expectation, severe cases of flat foot alignment tend to grow. Hindfoot arthritis are the next stage for these patients. Performing the calcaneal medializing correction can avoid this evolution (13,16,19). So, the best time to perform the procedure is after deformity but before arthritis, which means that the patient should be addressed in a lifetime when short recovery procedures are fundamental for early return to work, your understanding is that minimally invasive corrections will play a fundamental role in this new reality.

In the older population, longer or more aggressive surgeries with longer rehabilitation protocols make many patients ineligibles. Minimally invasive surgery with only two punctual incisions, regional block and the possibility of immediate weight bearing may be the best solution for these patients as well.

When doing the traditional technique for flat foot correction (Jonhson's type 2), after the Kouktsogiannis osteotomy and flexor digitalis longus to navicular or tibialis posterior, our group felt that in most cases a health tibialis posterior was found only with some degree of fat degeneration and synovitis (6,8). That impression went in the same direction of the recent literature, were the tibialis posterior insufficiency comes later after longer time of hindfoot progressive valgus alignment (14,20). Thus, bone correction when a not completely degenerated tibialis posterior is seen in MRI is a possible and less aggressive choice in elderly population. (14)

This paper is addressed to show the ventral position used at these cases, which in our opinion makes the procedure easier. The nerve block is made already in the ventral position not needing to change patient position. Lateral and axial view of the calcaneus are made by only rotating the C-arm.

Another differential of this position is that the medial approach can be made. In this surgery the greater risk is to injure the calcaneus branch of the tibial nerve, once it's the most posterior structure at medial side and is important for plantar sensibility. Laterally, several branches of the sural nerve are posterior, but they are responsible for a small not weight bearing area (21). This way, a medial approach gives a better control and protection of medial structures, and in lateral approach the incision is made in the traction side of the calcaneus, making it more difficult to heal. But we still need cadaveric studies to determine the safety.

We consider important the Achilles tendon stretching before the osteotomy. It makes the reduction easier; some similar articles show cases were the fragment makes a proximal migration (11). We consider the plantar positioning of the fragment to be essential for good correction. Thus, we observed less pain in patients submitted to the lengthening.

We had a clear impression that older patients are easier to operate, as the bone cut is softer, and they reported less pain in post operatory rehabilitation. So, this technique became our choice for patients over 50 years old.

## V. Conclusion

We described a new technique approach for minimally invasive flat foot correction that seems easier, faster and more reliable for fluoroscopic control. Further comparative studies are necessary to see evolution of these patients.

*Authors' contributions:* This manuscript is the result of the co-work of the authors and the job distribution ocurred as follows:

RSA performed the surgeries, created the technique modifications and participated in the manuscript writing

SAL made the literature revision and manuscript final edition

HCTR was the second surgeon of the surgeries and participated of the technique modifications creation

ALGS was the final revisor of the manuscript and made the post operatopry data compitation

JADL was responsible for the manuscript edition and writing and literature revision.

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## Figure Legends

*Figure 1:* Guide k-wire inserted thought the skin lateral (if lateral incision) to the bone. The surgeon is able to feel it so a straight line is easier to do with the Shannon burr. K-wire is positioned in the limit of the "safe zone" which is half way between calcaneal spur and fibula.

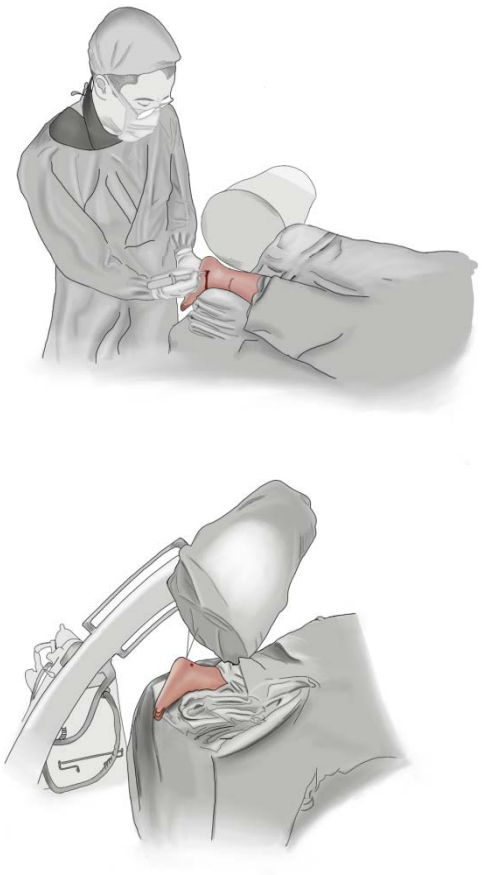

*Figure 2:* Intra-operatory Lateral and axial views.

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# Morphological and Histological Changes in Ligamentum Flavum in Degenerative Lumbar Canal Stenosis in Indian Population

By Ratnakar Ambade, N K Saxena & Arvind Bhake

*Abstract-* *Study Design:* Prospective multidisciplinary study — Clinical, radiologic and histological assessment using human samples of the lumbar ligamentum flavum.

*Objectives:* To evaluate Clinical, morphological, histological changes and relationship between inflammation and scar formation in ligamentum flavum in degenerative lumbar spine.

*Methods:* The thickness of 180 Ligamenta Flava at L2-L3, L3-L4, L4-L5, L5-S1 levels in 47 patients were measured using Magnetic Resonance Imaging. The relationship between thickness, age, and level was evaluated.

Histologic evaluation performed in 87 Ligamenta Flava samples obtained after 47 patients underwent decompressive surgery of the spinal canal. Trichrome stain, Verhoeff stain, and H & E stain were used. Degree of fibrosis, loss of elastic fibers and calcification were studied using the above-mentioned stains, respectively.

*Keywords:* *spinal canal stenosis, ligamentum flavum calcification, ligamentum flavum hypertrophy.*

*GJMR-H Classification:* *NLMC Code: WE 725*


*Strictly as per the compliance and regulations of:*

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***Results:*** The thickness of ligamentum flavum increased continuously with age. Thickness of the ligamentum flavum was highest at L4 - L5 level.

Histological evaluation showed that the percentage of Calcification increased with the increasing age. Fibrosis increased whereas elastic fibers decreased as the ligamentum flavum thickness increased.

***Conclusion:*** In our study, 80 of 87 ligaments were calcified ranging from extensive calcification to minimal calcification. All patients with symptoms severe enough to indicate decompressive surgery showed moderate to severe calcification in the ligament. A Histological study using Masons Trichrome staining showed positive linear correlation between Fibrosis score and ligamentum flavum thickness. Verhoeff staining showed that loss of elastic fibers correlated with ligamentum flavum hypertrophy.

*Keywords: spinal canal stenosis, ligamentum flavum calcification, ligamentum flavum hypertrophy.*

## I. Introduction

Lumbar spinal canal stenosis is the most common spinal disorder in elderly patients, which may lead to low back and leg pain, and paresis. Hypertrophy of the ligamentum flavum contributes in canal narrowing.[1]

In 1913, Elsberg first reported the case showing sciatica caused by the ligamentum flavum hypertrophy. Afterward, many clinical reports followed to indicate that ligamentum flavum hypertrophy was the main pathology inducing significant clinical symptoms in patients with lumbar spinal canal stenosis.[2]

Since then, others have suggested that the ligamentum flavum contributes to spinal disease, most prominently spinal stenosis. Furthermore, it is postulated that the ligamentum flavum hypertrophy may loose its elasticity and, thus, fold into spinal canal, which leads the compression of the dural tube.[3]

It is reported that in clinical and anatomical biomechanics, in extension the ligamentum flavum bulges inside the spinal canal or foramen and compresses nerve tissues.[4,5]

Thus, the morphological changes of the ligamentum flavum that are due to the change of lumbar spine alignment, as well as decrease in disc height associated with degeneration, may result in compression on nerve tissues. Fibrotic and chondrometaplastic changes occur in ligamentum flavum with aging.[6]

The present study was undertaken to know about morphological and histological changes that occur in ligamentum flavum with aging, in a spinal stenosis.

## II. Materials and Method

### a) Study Design

This prospective multidisciplinary study involving clinical, radiologic and histologic assessment using human samples of the lumbar ligamentum flavum was carried out in the department of Orthopaedics, Jawaharlal Nehru Medical College Wardha from October 2012 to April 2015. Total 47 patients enrolled in the study of those who came to our hospital after fulfilling the inclusion criteria. Out of these 47 patients, 28 were males, and 19 were females.

### b) Protocol And Technique

Forty-seven patients were diagnosed with Lumbar spinal canal stenosis (males - 28, females - 19), mean age - 50.51 years, (minimum- 41 years, maximum - 72 years).

Patients with a spinal deformity such as scoliosis or kyphosis, fracture spine or infection of spine were excluded from this study.

The study protocol was approved by the institutional ethics committee and, consent form signed by each subject.

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*Table No. 1*

| Spinal stenosis patients | No. of patients |
|---|---|
| Males | 28 |
| Females | 19 |
| TOTAL | 47 |

In standardized format, data concerning patients' history and clinical symptoms collected. The clinical complaint of low back pain was present in 42 of 47 patients five patients were without low back pain. 40 of 47 patients showed additional radicular symptoms. In all, 47 patients complained of neurogenic claudication (40 in combination with low back pain, seven without low back pain) with an average pain-free walking distance of 100 metres. All patients underwent MR Scan to confirm lumbar spinal stenosis, and that was consistent with pain pattern and level of neurologic deficit. All patients were clinically examined completely, including the neurological examination.

*Table 2:* Clinical signs and symptoms and neurological defects in patients with spinal stenosis (n = 35)

| Neurogenic claudication | |
|---|---|
| with low back pain | 40 |
| without low back pain | 7 |
| **Low back pain** | |
| with radicular symptoms | 35 |
| without radicular symptoms | 7 |
| **Neurologic Defects** | |
| Motor | EHL weakness - 15 |
| | Ankle weakness - 1 |
| Sensory | 14 |
| Reflexes | 10 |
| Lasegue's | 7 |

*c) Measurements of the Ligamentum Flavum*

All patients who were clinically diagnosed with having spinal canal stenosis in the lumbar region were sent for an MRI scan. Measurements of ligamentum flavum were taken as follows.

We used PACS software and a PACS workstation (GE Medical Systems, 1.5 Tesla) to measure the thickness of ligamentum flavum. The measurements were taken independently by two different persons including one radiologist.

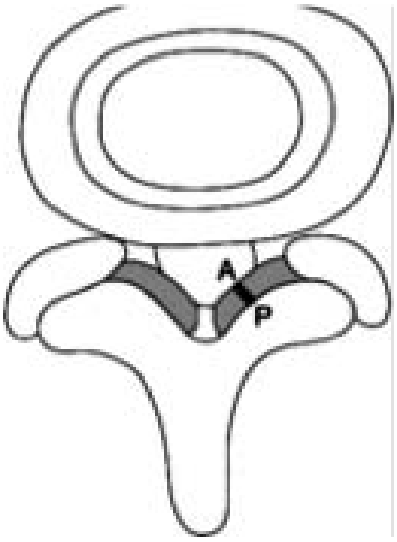


*Figure 1:* Measurements of ligamentum flavum thickness were carried out at the intervertebral disc level, perpendicular to the lamina border.

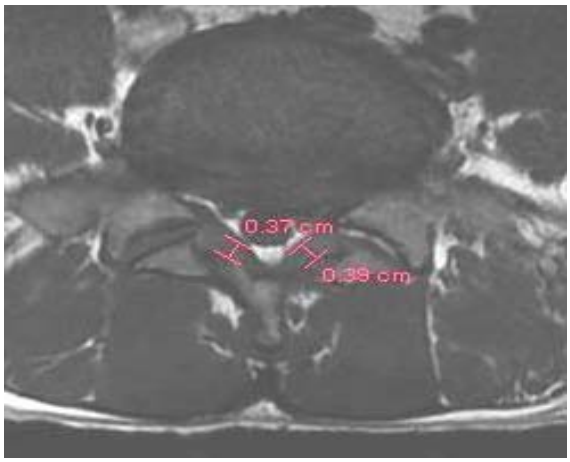


*Figure 1.1:* Measurements of ligamentum flavum

A Total of 180 ligamentum flavum was measured in 47 patients.

The right and left ligamentum flavum (LF) for the involved vertebral level was measured. Thickness at the middle portion of ligamentum flavum was measured. All measurements were taken by two persons separately and mean was calculated.

A total of 87 ligamentum flavum were harvested, using a standardized technique. Ligamentum flavum tissue was harvested at L3 - L4 in 13 patients, L4 - L5 in 38 patients and at L5 - S1 in 36 patients (Table. 5) from

total of 47 patients (men - 28, women -19) (mean age - 50.51 years).

*Table 4:* Levels at which Lig. Flavum was Harvested

| S NO. | LEVEL | NO. OF LIG. FLAVUM HARVESTED |
|---|---|---|
| 1 | L3 - L4 | 13 |
| 2 | L4 - L5 | 38 |
| 3 | L5 - S1 | 36 |
| | TOTAL | 87 |

*d) Histopathological analysis*

The harvested ligamentum flavum samples were fixed with 10% buffered formalin for 48 hours and then paraffin blocks were prepared.

Serial 4 μm thick sections were taken after being deparaffinized with xylene and replaced by ethanol. Stains used were hematoxylin and eosin stain, Trichrome stain and Verhoeff stain using standard methods. A light microscope (Olympus CH 21) was used.

1) *Trichrome Stain:* The degree of fibrosis was evaluated and graded concerning[ its severity (range 0-4).

Grade 0 – indicates normal tissue with no fibrosis Grade 1 – fibrosis ≤ 25 %
Grade 2 – between 25 % and 50 %
Grade 3 – between 50 % - 75 %
Grade 4 - ≥ 75 %.

2) *Verhoeff Stain:* The elastic fibers were stained. The loss elastic fibers were also graded; the same scoring system was used as the fibrosis score.

Grade 0 – black color stained all area of the ligamentum flavum, indicating rich elastic fibre content.

Grade 1 – loss of elastic fiber ≤ 25 %
Grade 2 – loss of elastic fibre between 25 % and 50 %
Grade 3 – between 50 % - 75 %
Grade 4 - ≥ 75 %.

3) *Haematoxillin & Eosin stain (Calcification)*

In H & E stain calcification stains bluish in color with the pink eosinophilic background. In slides with extensive calcifications, the areas stained bluish in color at many sites.

Two persons (R.A., an orthopaedic surgeon, and S.S., a pathologist) simply estimated these gradings. The relationships of these fibrotic, loss of elastic fiber scores, and calcification with the thickness of ligamentum flavum measured by T1 – weighted axial magnetic resonance imaging (MRI) examination before the surgery were evaluated at each site of the ligament.

## III. Results

*a) Gross*

The surface of ligamentum flavum on the ventral side is not uniform and smooth always. It ranges from smooth to eroded, creases in the ligamentum flavum as results of folding of the ligament. The dorsal side was never smooth it was in all cases irregular, thick, rough, and hypertrophied.

*b) Clinical study*

Ligamentum flavum thickness was measured in total of 180 ligaments on T1 weighted axial images on plain MR Scan. Overall the thickness increased with age at all levels however, the increase was most pronounced at L4/L5.

*Table No. 6:* Mean Thickness of Lig. Flavum

| SPINAL LEVEL | NO. OF LIGAMENTUM FLAVUM | MEAN THICKNESS (mm) |
|---|---|---|
| L1/L2 | 2 | 3.1875 |
| L2/L3 | 5 | 3.63 |
| L3/L4 | 14 | 3.680 |
| L4/5 | 33 | 4.535 |
| L5/S1 | 33 | 3.8 |

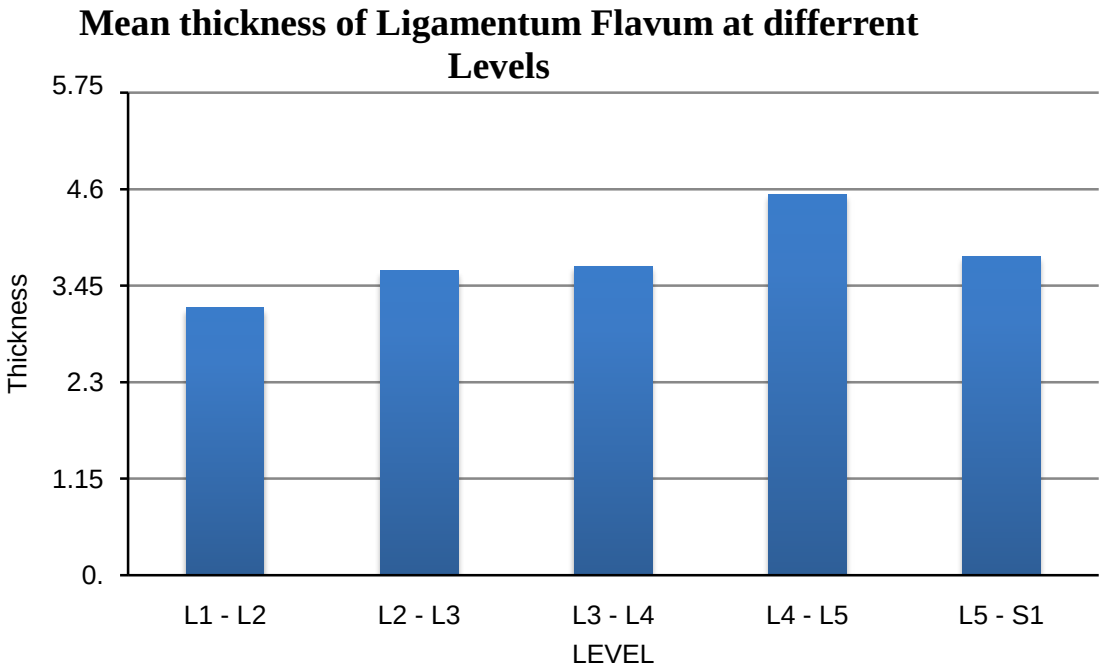


*Fig. 4:* Changes in thickness with aging at each spinal vertebral level.

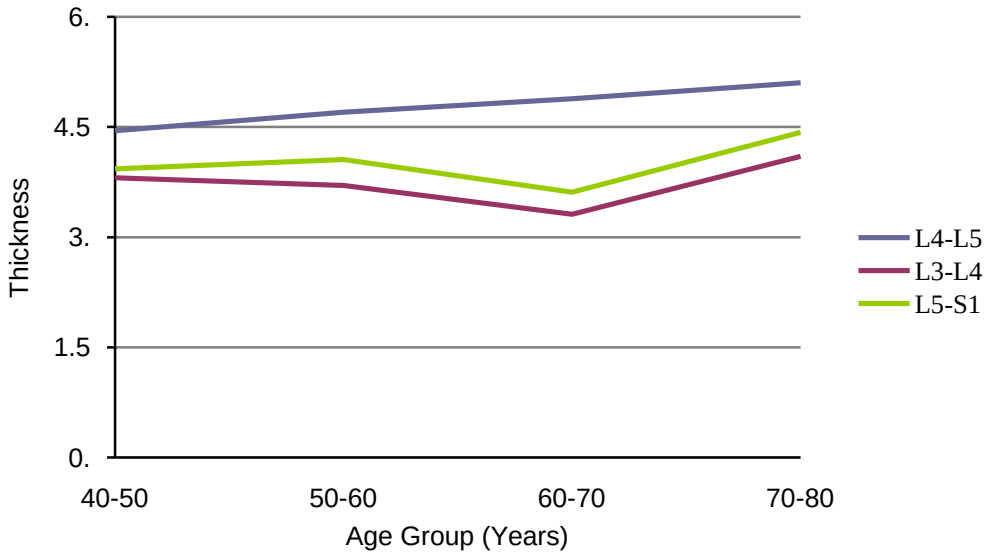


*Fig. 5:* Mean thickness of ligamentum flavum in different age groups at L3-L4, L4-L5, L5-S1 level.

*Table No. 7:* Ligament Thickness at L3 - L4 Level

| AGE (years) | NO. OF PATIENTS | MEAN THHICKNESS (mm) | MINIMUM THICKNESS (mm) | MAXIMUM THICKNESS (mm) |
|---|---|---|---|---|
| 40 - 50 | 5 | 3.81 | 3.125 | 4.775 |
| 50 - 60 | 4 | 3.706 | 3.375 | 4.225 |
| 60 - 70 | 4 | 3.312 | 2.925 | 3.6 |
| 70 - 80 | 1 | 4.1 | — | —- |

*Table No. 8:* Ligament Thickness at L4 - L5 Level

| AGE (years) | NO. OF PATIENTS | MEAN THICKNESS (mm) | MINIMUM THICKNESS (mm) | MAXIMUM THICKNESS (mm) |
|---|---|---|---|---|
| 40 - 50 | 19 | 4.510 | 3.2 | 5.25 |
| 50 - 60 | 10 | 4.7525 | 4.0 | 5.5 |
| 60 - 70 | 5 | 4.838 | 4.45 | 5.0 |
| 70 - 80 | 1 | 5.1 | —— | 5.1 |

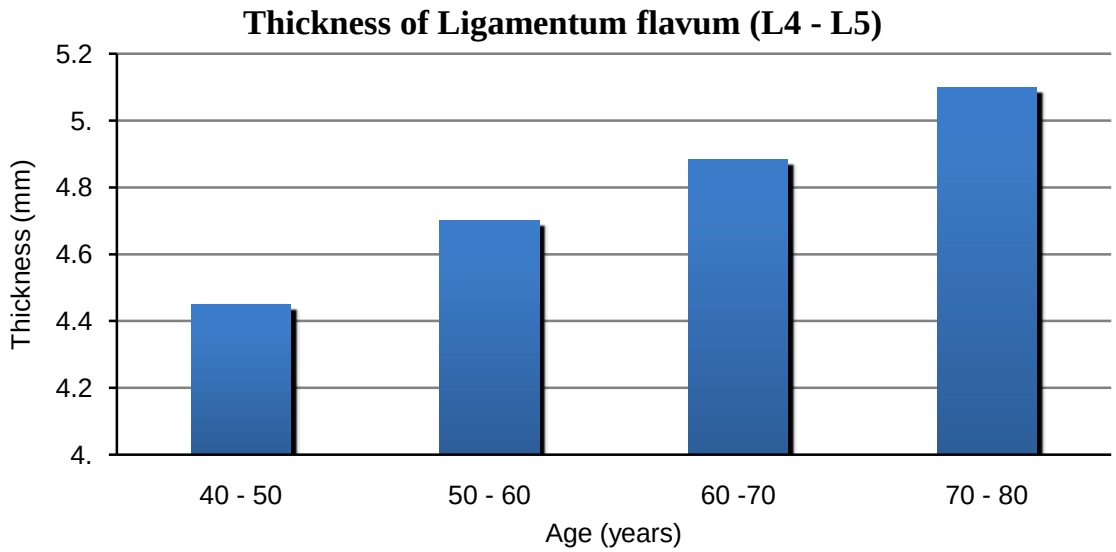


*Fig. 6:* Mean thickness of ligamentum flavum at L4-L5 in Different age groups

*Table No. 9:* Ligament Thickness at L5 - S1 Level

| AGE (years) | NO. OF PATIENTS | MEAN THICKNESS (mm) | MINIMUM THICKNESS (mm) | MAXIMUM THICKNESS ( mm) |
|---|---|---|---|---|
| 40 - 50 | 17 | 3.930 | 2.355 | 5.075 |
| 50 - 60 | 9 | 4.055 | 2.825 | 4.675 |
| 60 -70 | 5 | 3.61 | 3.025 | 4.4 |
| 70 - 80 | 1 | 4.425 | | |

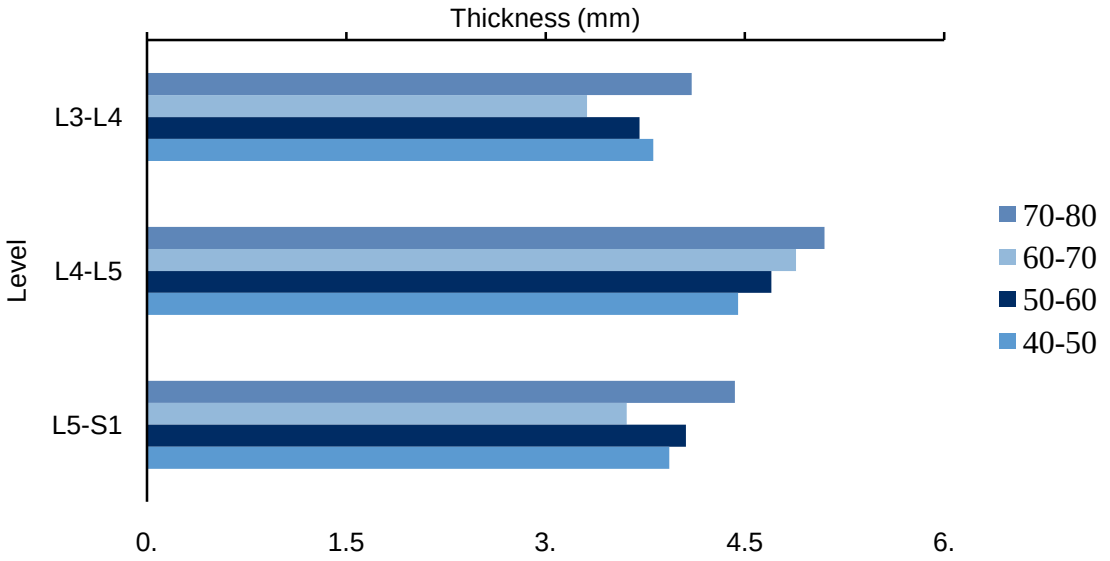


*Fig. 7:* Shows thickening of ligamentum flavum at L3 -L4, L4 - L5 and L5 - S1 levels at different age groups.

The thickness of ligamentum flavum at L4/L5 levels continuously increased with age. The mean thickness of the ligamentum flavum in all patients was 3.1875 mm, 3.63 mm, 3.680 mm, 4.535 mm and 3.8 mm for L1/L2, L2/L3, L3/L4, L4/L5 and L5S1 levels, respectively. The thickness of the ligamentum flavum was highest at the L4/L5 level.

The ligamentum flavum at L5 - S1 level increased with age except in the age group 60 - 70, less number of subjects may be a reason. However, ligament thickness at L3 - L4 level do not show an increasing trend with age, may be a larger number of subjects at this level can give a more accurate result. However, an increasing trend was found between increasing age groups and thickness of ligamentum flavum at L4 -L5 level as the thickness of ligamentum flavum at L4 - L5 level continuously increased with age though the correlation was not statistically significant.

*c) Histological Evaluation of the Ligament*

A total of 87 ligamentum flavum were harvested. Ligamentum flavum tissue was harvested at L3 - L4 in 13 patients, L4 - L5 in 33 patients, and L5 - S1 in 33 patients from total of 47 patients (men - 28, women -19) (mean age - 50.51 years) (Table. 5).

*Table No. 11:* No. of Lif. Flavum Harvested

| S NO. | LEVEL | NO. OF LIG. FLAVUM HARVESTED |
|---|---|---|
| 1 | L3 - L4 | 13 |
| 2 | L4 - L5 | 38 |
| 3 | L5 - S1 | 36 |
| | TOTAL | 87 |

*Table No. 12:* Trichrome stain (fibrosis score)

| FIBROSIS SCORE (GRADE I - IV) | MEAN THICKNESS (mm) | MINIMUM THICKNESS (mm) | MAXIMUM THICKNESS (mm) |
|---|---|---|---|
| GRADE - I | 4.35 | 3.2 | 4.95 |
| GRADE - II | 4.50 | 4.0 | 4.875 |
| GRADE - III | 4.569 | 4.025 | 5.25 |
| GRADE - IV | 5.01 | 4.25 | 5.75 |

The Mean thickening of the ligamentum flavum increased with increasing grade of the fibrosis, showing a strong linear correlation, which is also statistically significant (p - value $<$ 0.05).

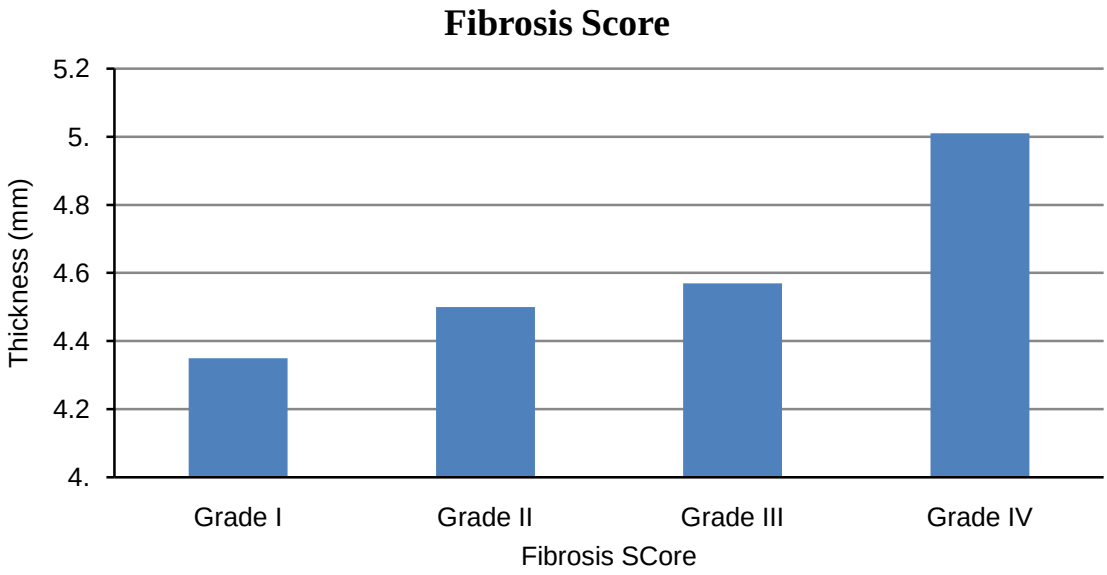


*Fig. 9:* Shows the correlation between the fibrotic score for the entire ligamentum flavum and the thickness of the ligamentum flavum.

The relationship between ligamentum flavum thickness and fibrosis score showed positive linear, strong correlations. ($P$ - *value* $< 0.05$).

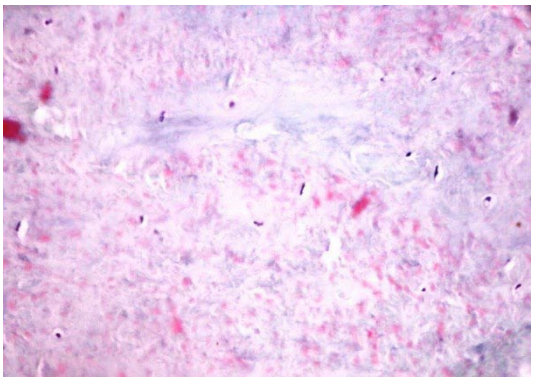

*Figure 10:* GRADE - I

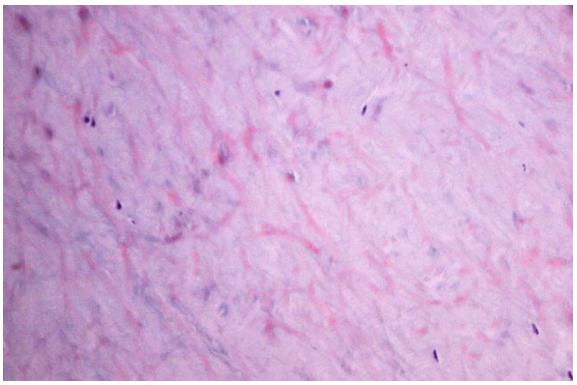

*Figure 10.1:* GRADE - IV

Fig. 10. & Fig. 10.1 In grade I all area of the ligamentum flavum was stained an eosinophilic pink colour, and a blue color stained the minimum area, indicating fibrosis. On the other hand, in grade IV, blue - stained most of the areas, indicating that most of the area showed fibrosis.

*Table No. 13:* Verhoeff Stain (Loss of Elastic Fibre)

| LOSS OF ELASTIC FIBER SCORE | MEAN THICKNESS (mm) | MINIMUM THICKNESS (mm) | MAXIMUM THICKNESS (mm) |
|---|---|---|---|
| GRADE - 0 | 4.13 | 3.2 | 4.95 |
| GRADE - I | 4.41 | 3.825 | 5.25 |
| GRADE - II | 4.70 | 4.325 | 5.0 |
| GRADE - III | 4.870 | 4.65 | 5.25 |
| GRADE - IV | 5.15 | 4.85 | 5.65 |

*d) Loss of Elastic Fibre Score Compared with Mean Thickness of Ligamentum Flavum*

An increasing trend was found when Loss of elastic fibre score was compared with the mean thickness of the ligamentum flavum. The thickness of the ligamentum flavum increased with the increasing grade of loss of elastic fiber group. The relationship between ligamentum flavum thickness and loss of elastic fibre score showed positive linear, relatively strong correlations. *(P value* $< 0.05$.)

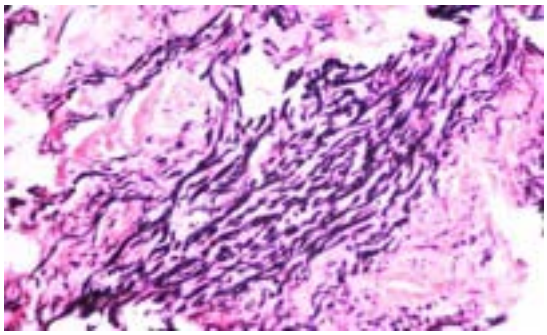

*Figure 11:* GRADE I

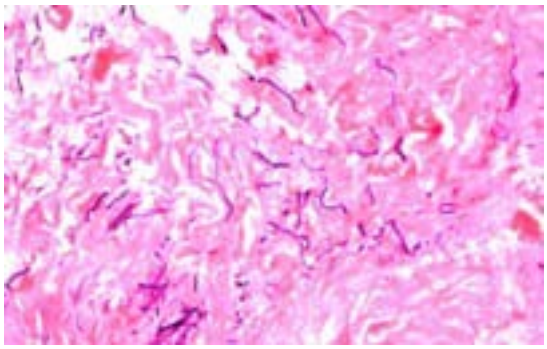

*Figure 11.1:* GRADE IV

Fig. 11 & 11.1 represents the histology of the severely hypertrophied ligament; less elastic fibers were stained with Verhoeff stain in grade IV. On the other hand, the elastic fibers were well stained in grade I.

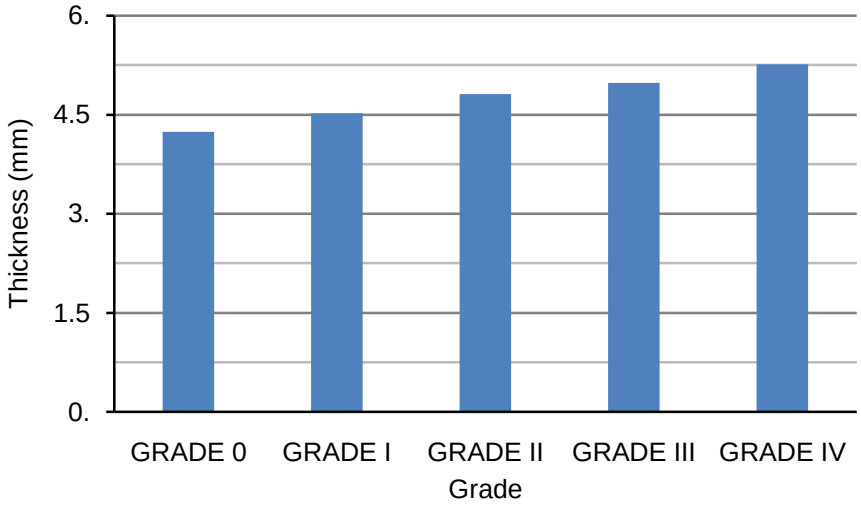


*Fig. 12:* Mean thickness of ligamentum flavum in different grades of loss of elastic fibre score

*e) Calcification*

In patients with lumbar spinal stenosis, 83 of 87 ligaments were calcified.

All patients in whom calcification was found in the ligamentum flavum were divided into three groups. Patients were classified into three age groups as follows:

1. Those aged 40 - 50 years (19 biopsies)
2. Those aged 50–60 years (26 biopsies)III - those aged above 60 years (18 biopsies).

*Table 15:* Calcification in Different Age Groups

| AGE GROUP | NO. OF PTS | NO. OF LIG FLAVUM | CALCIFICATION |
|---|---|---|---|
| I (above 60 years) | 6 | 18 | 18 |
| II (50 - 60 years) | 10 | 26 | 24 |
| III (40 - 50 years) | 19 | 43 | 41 |
| TOTAL | 35 | 87 | 83 |

The percentage of calcification increased with age across the three groups (I> II > III) (Table 3). An increasing trend could be seen in the calcification as the percentage of calcification increases with the increasing age. However, it is statistically not significant.

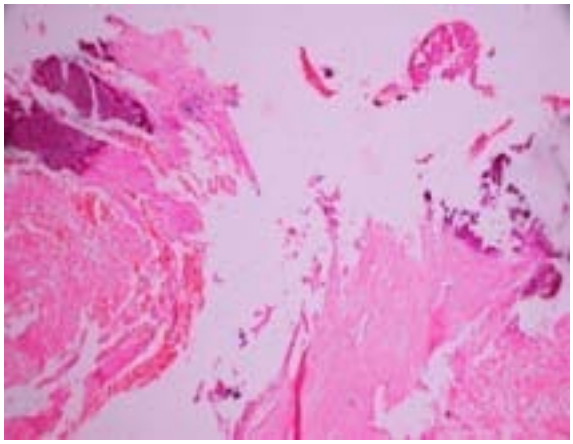

*Figure 13:* Minimal Calcification (slide a)

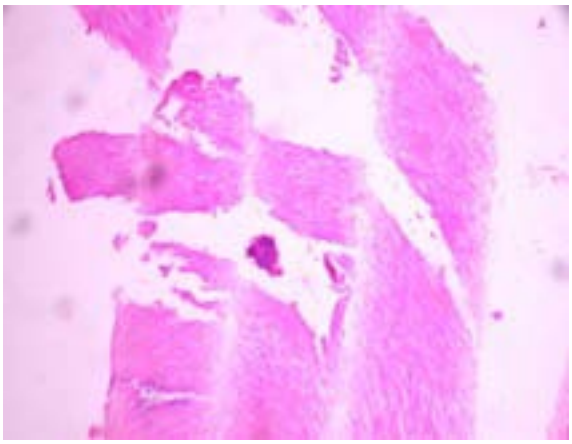

*Figure 13.1:* Extensive Calcification (slide b)

Fig. 13 & 13.1 E stain (arrow), histopathological sections in slide 'a' showing H & with minimal calcification stained bluish with the pink eosinophilic background. Where as in slide 'b' the areas stained bluish in color have increased and can be seen at many sites (arrows) suggesting extensive calcification.

A relationship between age and degree of calcification could only be seen as a trend (the older, the more calcified), but was statistically not significant ($P > 0.05$).

*Table No. 17*

| CALCIFICATION | MEAN THICKNESS (mm) | MINIMUM THICKNESS (mm) | MAXIMUM THICKNESS (mm) |
|---|---|---|---|
| NO CALCIFICATON | 4.005 | 3.0 | 4.75 |
| MINIMAL | 4.545 | 4.0 | 4.95 |
| MODERATE | 4.606 | 4.125 | 5.3 |
| EXTENSIVE | 5.103 | 4.325 | 5.875 |

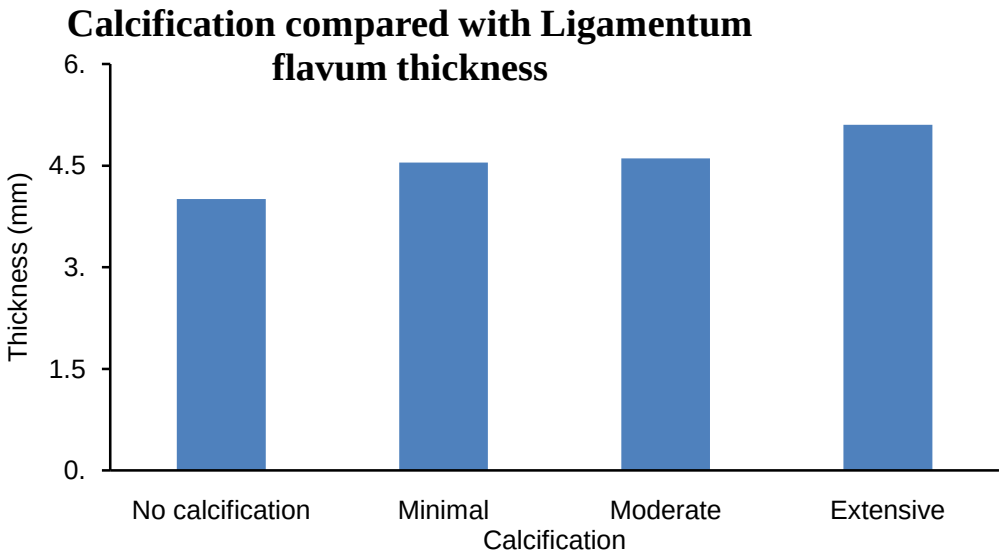


*Fig. 14:* Calcification compared with the mean thickness of ligamentum flavum

## IV. Discussion

The ligamentum flavum covers the posterior wall of the spinal canal. Thus as the ligamentum flavum hypertrophies, it will compress the spinal cord, cauda equina, or nerve root. Hypertrophy of ligamentum flavum is one of the major factors of canal narrowing in lumbar spinal canal stenosis. Numerous studies have

investigated the mechanism of ligamentum flavum hypertrophy from the view points of anatomy, histology, and biology.

To date, few viable hypotheses have been established regarding the pathomechanism of ligamentum flavum hypertrophy.

In our present study, we have carried out a clinical, radiological, and histological study on ligamentum flavum.

The causes of ligamentum flavum hypertrophy are multifactorial, including activity levels, age, and mechanical stress. To elaborate on these causes in detail, several attempts have made in the literature to clarify the pathomechanism of the ligamentum flavum hypertrophy.

*a) Clinical study*

*GROSS:* The surface of ligamentum flavum on the ventral side is not uniform and smooth it always ranges from smooth to eroded, creases in the ligamentum flavum as results of folding of the ligament. The dorsal side was never smooth. It was in all cases irregular, thick, rough, and hypertrophied. These findings are consistent with Teruaki Okuda et al.[7] In the present study we measured the thickness of 180 ligamenta Flava from 47 subjects in the age groups ranging from 40 to 80 years age (Mean age - 50.51 years) in Lumbar spinal stenosis patients. The thickness of ligamentum flavum was found to increase with age. A trend can be seen that the thickness of ligamentum flavum increases with age; however statistically, r it was not significant. However, the changes with age showed spinal level dependence. The increase in thickness with age was largest at L4/L5, probably because of increased mechanical stress at this level. These findings are consistent with the results of Koichi Sairyo et. al (2005).[8]

The lumbar spinal canal varies in shape and may be an oval, rounded triangular or trefoil configuration. The trefoil configuration usually is more common at the fifth lumbar level, making L4-L5 the narrowest level.[9]

Although factors like body weight, activities of daily living, could affect the ligamentum flavum the thickness but not considered in the present study. The purpose of the present study was to understand the natural course of the variations in thickness of the ligamentum flavum. Koichi Sairyo, Vijay Goel et. al [8] discovered the loading mode that will relatively induce the most tensile stress. They observed that maximum stress was observed in flexion mode. Thus, a mode that requires flexion, such as lifting, may lead to ligament hypertrophy.

In 1938 Naffziger et al. [9] was the first to state that hypertrophy of the ligamentum flavum was the result of injury with scar formation.

Similarly, in 2005, Koichi Sairyo, Vijay Goel et al. reported that the dorsal side of ligamentum is highly stressed during the activities of daily living. During lumbar motion, mechanical stress causes damage in the ligament, and the repairing process in the ligament fibrosis occurs similar to scar formation. [8]

*b) Histologic study*

In our study, we also focussed on major histological changes. A total of 87 ligamenta Flava were harvested during surgery from the spinal canal stenosis patients and subjected to the histological examination. The following stains were used 1) Haematoxillin and Eosin stain 2) Masons Trichrome stain 3) Verhoeff stain. Eighty - seven ligaments were stained with H & E staining and Trichrome stain, whereas 30 ligaments were stained with Verhoeff stain.

*c) Fibrosis (Trichrome stain)*

The fibrosis score showed a positive linear correlation with ligamentum flavum thickness, and statistically, it was significant ($p$ - *value* $< 0.05$). In our histological study using Mason's trichrome staining the fibrosis appeared in all areas of a hypertrophied ligamentum flavum. Fibrosis is a type of scarring that occurs as a result of an injury. Scar formation has been reported in the repair process following injuries in ligaments such as medial collateral ligament of the knee joint therefore hypertrophied ligamentum flavum could have suffered a stress - related injury leading to scar formation.

These findings are consistent with the results of Koichi Sairyo et. al. [8] They reported in their study that the accumulation of scar tissue could be an important factor in the development of ligamentum flavum hypertrophy. The dorsal layer showed the most pronounced fibrotic damage.

*d) Elastic fibers (Verhoeff stain)*

It has been reported that in young ligamentum flavum, the elastic fiber content is high, and it decreases with aging. [10]

This collagen/elastin conversion is considered to be one of the pathomechanisms of ligamentum flavum hypertrophy. In our study, the histologic results with Verhoeff staining showed that the loss of elastic fibers correlated with ligamentum flavum hypertrophy. Thus it supports the theory that increased collagen (fibrosis) could be the main factor in collagen/elastin conversion without decreasing the elastic fiber content.

It was noted in our study even in Grade I, the elastic fibers was not parallel as it is noted in non-degenerative ligamenta Flava, i.e the fibers should appear parallel. This was consistent with Menson and Fender. [11]

Our study also showed that this parallel order was disturbed in the ligamenta flava in a lumbar spinal

stenosis. These findings are consistent with the results of Yoshida et al. [12]

Also, Peter K. Schräder et. al[13] measured every fiber angle in the ligament; they proved that the parallel order of the elastic fibers is lost in a degenerative lumbar spinal stenosis.

*e) Calcification*

Calcification of the ligamentum flavum is reported to appear more often in combination with other degenerative changes of the spine. Avrahami et al. [14] indicate an incidence of 80% in a group of 30 patients with radiologically confirmed lumbar spinal stenosis. Calcification of ligamentum flavum is a rare entity, reported more commonly in patients from Japan and the French Antilles. It is usually seen in middle-aged women and most commonly affects the cervical spine. It is thought to be due to deposits of calcium pyrophosphate within the ligamentum flavum. The calcification may be symptomatic if it abuts the spinal cord, and surgery usually helps for symptomatic patients. Although this fact is considered a manifestation of degenerative disease of the spine.[15]

Calcification is common in the Asian population in the lower thoracic and cervical spine and rare in the western population. In our study 80 of 87 ligaments were calcified ranging from extensive calcification to minimal calcification. [16]

Our findings confirm that clinical symptoms of lumbar spinal canal stenosis are associated with calcification of the ligamentum flavum. Patients with symptoms that were severe and surgery were indicated showed moderate to severe calcification in the ligament.

Baba et al. [17] reported in five patients who underwent lumbar decompressive surgery for cauda equina syndrome and radiculopathy secondary to degenerative stenosis and were associated with calcium deposition in the ligamentum flavum. Histology proved degeneration in elastic fibers and calcium deposition in the ligamentum flavum. This was interpreted as being associated with the degenerative process in the ligament, and changes were suspected as causing or aggravating the neurological symptoms also quantitative analysis of calcification was not performed in their study. No information is given to describe the degree of degeneration of elastic fibers.

Yoshida et al. [12] studied 45 cases of lumbar spinal stenosis by CT and pathologic and immuno-histochemical studies. The control group included, ten cases of acute disc herniation. Statistically significant differences in thickness and transverse area of ligamenta flava were found compared to the controls. The pathogeneses of the hypertrophied ligamentum flavum were divided into three major groups: (1) fibrocartilage change due to proliferation of type II collagen, (2) ossification, and (3) calcium crystal deposition.

Postacchini et al. [10] examined ligamenta flava obtained from nine lumbar disc herniation patients and ten patients with lumbar spinal stenosis. The ligaments were studied histologically, histochemically, and at ultrastructural levels. Controls comprised ligaments from six patients undergoing surgery for thoracolumbar fractures. In lumbar spinal stenosis, degenerating elastic fibres were seen occasionally, calcification could also be seen often. Histological findings of degeneration were observed in controls aged 50 or older.

Schrader et al. [13] evaluated twenty-one patients (13 men, 8 women, age range 44 - 80) who underwent decompressive surgery of the spinal canal due to signs and symptoms of degenerative lumbar spinal stenosis. In patients with lumbar spinal stenosis, 35 of 38 ligaments were calcified. As the distribution of age was heterogenous, the degree of calcification about the age was set. The percentage of calcification increased with age across the three groups. The control group, 3 of 20 ligaments showed minimal calcification.

Due to the close proximity of ligamentum flavum to the dura and spinal nerves, it is obvious that ligamentum flavum may contribute considerably to the pathogenesis of lumbar spinal stenosis.

Our analysis of calcification of the ligamentum flavum proves that this degenerative process can cause sciatic or neurological clinical findings in a lumbar spinal stenosis. These findings are consistent with the results of Schrader et al. [13]

Postacchini et al [10] found age - related changes in the ligamentum flavum. These findings are consistent with our results.

Thus it can be assumed that apart from reduced elasticity of the ligamentum flavum a concomitant increase of volume of the ligament due to calcification and reduction of elastic fibers may contribute to the pathogenesis of lumbar spinal canal stenosis. Many authors in the past have described an association between changes in the ligamentum flavum and degenerative lumbar spinal stenosis.

In the present study, we have described the role of calcification in ligamentum flavum hypertrophy, these findings are consistent with the results of Schrader et al.[13]

Kazuo Miyasaka, Kiyoshi Kaneda, et al. reported that ossification and calcification of the ligamentum flavum have different clinical, radiologic, and histologic presentations.

The etiology and mechanism of calcification remain unclear, but probably are distinct from those of ossification.

Hypertrophy of LF is considered an important causative factor in the development of lumbar spinal stenosis (compression of the dural sac and roots) and significantly contributes to low back pain and sciatica.

However, there are multiple factors leading to Lumbar canal stenosis. In our study in patient no: 19 though the clinical symptoms were severe the ligamentum flavum hypertrophy was fewer as compared to other patients who had less symptoms so it can be stated that LF hypertrophy is not the only factor leading to lumbar canal stenosis, other factors like the shape of the canal, bony spurs, facet joint arthropathy, spondylolisthesis, and other degenerative processes are also responsible for Lumbar canal stenosis. Hence during the surgical decompression for lumbar canal stenosis, the exact cause of the symptoms should be considered, so that the symptoms of the suffering patient are taken care of.

## V. Conclusion

We can conclude from our study.

1. Ligamentum flavum hypertrophy compresses the spinal cord, cauda equina, or nerve root and is one of the major factors of canal narrowing in lumbar spinal canal stenosis. The causes of ligamentum flavum hypertrophy are multifactorial aging (degenerative process) being one of them.
2. Fibrosis (scarring) occurs in hypertrophied ligamentum flavum, or it can also be proposed that accumulation of scar tissue can lead to ligamentum flavum hypertrophy. Scar formation occurs as a repair process following injury.
3. The elastic fiber content decreases with aging (degenerative process).
4. Calcification was noted the majority of hypertrophied ligaments, and it was more extensive in the spinal stenosis patients. It can also be proposed that calcification (as a degenerative process) can cause neurological clinical findings in a lumbar spinal stenosis.

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# Catastrophic Tibiofibular Trunk Injury Following Fixation of Tibial Spine Fracture

By Túlio Vinícius de Oliveira Campos, Guilherme de Castro Santos, João Vitor Oliveira Souto, Guilherme Moreira Abreu e Silva, Robinson Esteves Pires, Robert C Schenck Jr, Túlio Pinho Navarro & Marco Antônio Percope de Andrade

*Universidade Federal de Minas Gerais*

*Abstract-* Arthroscopic treatment for fractures of the tibial spine is supposed to afford a more accurate approach to the fracture site, decreased morbidity, earlier mobilization, and a shorter hospital stay. We report the accidental lesion of the tibiofibular branch of the popliteal artery during screw fixation of an ACL osseous avulsion using the arthroscopic assisted technique. Until now, there is no report of vascular injury during fixation of the tibial spine using this technique.

*Keywords:* *ACL avulsion; arthroscopy; vascular.*

*GJMR-H Classification:* *NLMC Code: WE 175*


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*Keywords: ACL avulsion; arthroscopy; vascular.*

## I. Introduction

Fracture of the tibial spine is a typical lesion of subjects with an immature skeleton. The mechanism of injury comprises knee flexion, external rotation of the tibia and valgus stress. The lesion is characterized by an avulsion fracture including the insertion of the anterior cruciate ligament (ACL). Surgical treatment is required for deviated fractures and includes fixation of the fragment by a traction screw or transosseous suture after reduction undertaken by direct or arthroscopic vision. Arthroscopy is supposed to afford a more accurate approach to the fracture site, decreased morbidity, earlier mobilization, and a shorter hospital stay, compared with open reduction. However, it may be technically difficult and carries a steep learning curve. (Strauss et al. 2018).

Vascular injury is a rare complication of knee surgery, but surgeons should always consider this in patients who have undergone knee arthroscopy. (Xu et al. 2017) Pioneer studies compiling arthroscopy complications reported incidence of vascular injuries in 1% of procedures. (DeLee 1985) Veselko et al, considered arthroscopic assisted screw fixation of the ACL avulsion a simple, safe and reproducible procedure. (Veselko, Senekovic, and Tonin 1996; Senekovic and Veselko 2003).

Our aim is to report the lesion of the tibiofibular branch of the popliteal artery while screw fixation of an ACL osseous avulsion using the arthroscopic assisted technique.

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## II. Case Report

A 16 year old male patient went on a motorcycle accident. He developed right knee hemarthrosis, anterior instability and an isolated avulsion fracture of the ACL tibial insertion caused by a rotational mechanism (Figure 1).

*Figure 1:* Lateral x-ray and CT images showing the avulsion fracture of tibial spine. A robust anterior fragment allowed screw fixation.

Surgical planning comprised arthroscopic assisted reduction and minimally invasive fixation of the avulsed fragment by a small fragment cannulated screw and washer.

The senior surgeon (TVOC) which was maintaining the fragment reduced under arthroscopic view noticed that his assistant progressed the drill beyond the posterior tibial cortex. In addition, the x-ray evaluation of the screw's position alerted the team to the possibility of a vascular injury as the screw was aiming at the region of the tibiofibular trunk. (Figure 2)

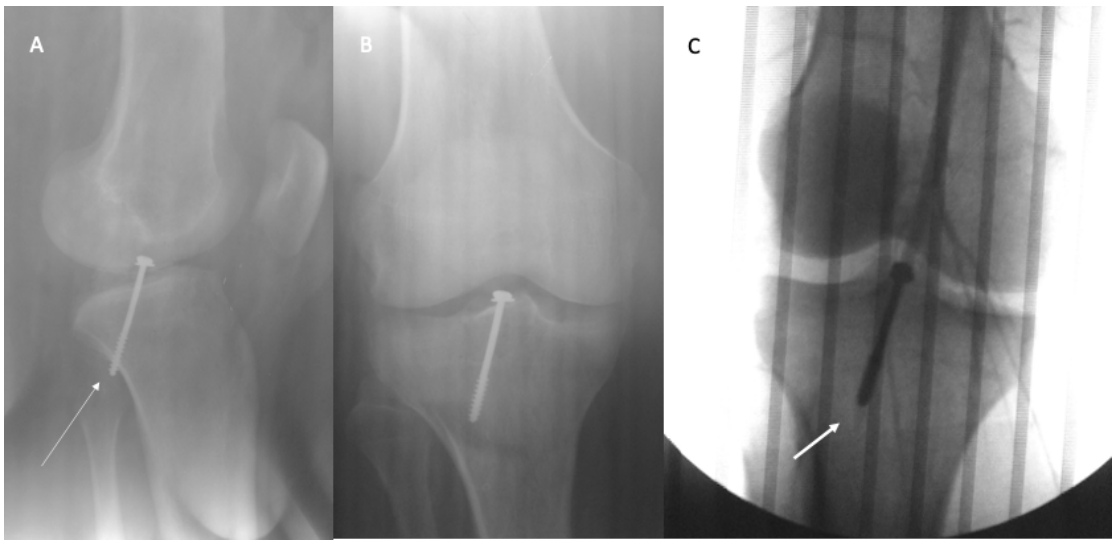


*Figura 2:* A and B - White arrow points to the end of the screw which crosses the posterior cortex of the tibia and goes toward the popliteal vessels. C - Arteriography shows interruption of the flow distal to the screw (white arrow).

The tourniquet was released and the vascular status checked. There was an evident reduction in dorsalis pedis and posterior tibial artery pulses when compared to the contralateral side. Limb perfusion presented a delayed distal filling. The vascular surgeon was immediately called and an ultrasound Doppler revealed a monophasic arterial flow distal to the tibiofibular trunk. An arteriography diagnosed an interruption of contrast flow in the tibiofibular trunk, no contrast leakage and normal filling of collaterals that probably maintained the limb perfusion.

Based on arteriography, our first hypothesis was a tibiofibular trunk obstruction linked to screw distal compression. As a result a change in screw position and size reduction was attempted in order to relieve compression in the vessel wall. The measure was ineffective for restoring distal arterial flow. Thus, it was decided to make a by-pass using the great saphenous vein bridging the region of interrupted blood flow. (Figure 3)

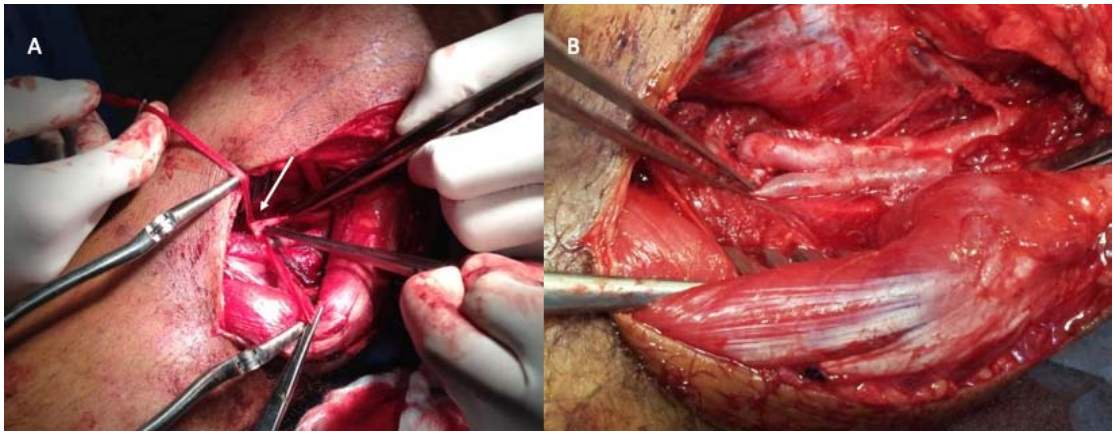


*Figure 3:* A - perforation of the tibiofibular trunk wall. There was no haematomaas arterial thrombosis occluded the vessel wall hole. B - Bypass with a functioning great saphenous vein.

Anticoagulant prophylaxis comprised rivaroxaban 10mg for 4 weeks. The range of movement physiotherapy exercises were delayed for 2 weeks. The patient had a 7yr follow up consultation in which it was possible to assess fracture healing and normal knee function. The patient resumed his activities as a waiter without complaint of pain or instability.

## III. Discussion

Fracture of the tibial spine is a rare injury that occurs mainly in patients with immature skeletons. This region represents the ACL insertion site and the diagnosis is made by clinical history, physical examination, radiography, and computed tomography. Magnetic resonance imaging can identify associated lesions, mainly the lesion of the anterior horn of the lateral meniscus that may impair reduction of the fragment.

Arthroscopic reduction of the ACL fragment is less invasive and permits treatment of associated injuries. Fixation may be achieved by transosseous suture, anchor or screws that provide stability to the fragment until consolidation. In open surgery, both hands of the senior surgeon are free to perform main procedure steps. In arthroscopic surgery, one of the surgeon's hands is occupied holding the video camera. As a result, there are two options: 1) ask the assistant to create the screw tunnel or 2) do it himself while the assistant keeps the fragment reduced. In both situations, the surgeon's hand control is decreased and the risk of violation of the posterior tibial wall is increased.

Post et al, using cadaver specimens addressed the anatomic position of the popliteal vessels and tibiofibular trunk. They alert about anatomic variations that may occur, recommend knee flexion and caution while perforating the posterolateral tibial cortex. This case report alerts surgeons for an inadvertent vascular injury during fixation of ACL avulsion fracture. The direction of the drill and screw might head to the vascular bundle if they come from superomedial to inferolateral.

Palazzolo et al, reviewed uncommon complications after ACL reconstruction. They described three cases of vascular lesions. Most presented clinically by haematoma and bleeding. (Palazzolo et al. 2018) In our case, the occurrence of thrombosis at the injury site prevented the development of an expanding hematoma. Thus, suspicion was based on the presence of pulse asymmetry and changes detected in the doppler evaluation. Confirmation of the diagnosis was achieved by arteriography. The challenge is to diagnose the lesion in an anesthetized limb with preserved perfusion by the collaterals. Therefore, the suspicion may be supported by anatomical knowledge.

Keyurapan *et al*, studied the posterior region of the extended and flexed knee using magnetic

resonance imaging. The authors concluded that knee flexion increases the distance between the neurovascular bundle and the posterior tibial wall. In addition, flexion of the joint moves the bundle to the posterolateral region. This work reinforces concern while approaching the posterolateral region of the tibia and the need to carefully assess vascular status whenever the posterior cortex is violated. Most ACL avulsion fractures are reduced by knee extension which approximates the vascular bundle and the posterior cortex. (Keyurapan, Phoemphunkunarak, and Lektrakool 2016).

The evaluation of vascular lesions around the knee may challenge even experienced surgeons. The clinical evaluation is tricky and physical exam findings may range from complete pulse absence and lack of perfusion to delayed presentation which includes swelling and unexplained pain. (Xu et al. 2017).

There is no record in the literature of vascular injury during fixation of avulsion of the tibial spine. The reports are of vascular injury during ACL reconstruction, and in all cases, the patients did not present changes in their pulses after the injury. The diagnosis was made based on the identification of an expanding hematoma or compartment syndrome in the days following the surgical procedure. In the case presented in this study, the diagnosis was precocious since knowledge about the probable path of the vascular bundle triggered the early investigation. The quickness of the diagnosis allowed the patient to have a satisfactory clinical evolution without any type of sequel. (Palazzolo et al. 2018).

## IV. Conclusion

Vascular injuries can occur during fixation of the tibial spine fracture. The knowledge of anatomy allows the early identification of this type of complication and its effective treatment.

*Declarations:*

*Conflict of interest*

Authors declare that they do not have any conflict of interest related to that paper.

*Funding*

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*Ethical approval*

As a case report, ethic approval is not required according to Brazilian ethics committee.

*Informed consent*

Informed consent has been obtained from the patient. He agreed to have his case description published in benefit to orthopaedic community knowledge improvement.

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Nothing to declare

*Authors' contribution*

Tulio Campos; Guilherme de Castro; Guilherme Moreira; Robinson Esteves; Tulio Pinho; Marco Antônio had participation in surgical field and contributed to manuscript. João Victor and Robert Schenck Jr contributed to case report and revision of the paper.

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g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

## Format Structure

***It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.***

All manuscripts submitted to Global Journals should include:

**Title**

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

**Author details**

The full postal address of any related author(s) must be specified.

**Abstract**

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

**Keywords**

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, “What words would a source have to include to be truly valuable in a research paper?” Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

**Numerical Methods**

Numerical methods used should be transparent and, where appropriate, supported by references.

**Abbreviations**

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

**Formulas and equations**

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

**Tables, Figures, and Figure Legends**

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

**Figures**

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

## Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

## Tips for writing a good quality Medical Research Paper

***1. Choosing the topic:*** In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

***2. Think like evaluators:*** If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

***3. Ask your guides:*** If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

***4. Use of computer is recommended:*** As you are doing research in the field of medical research then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

***5. Use the internet for help:*** An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

***6. Bookmarks are useful:*** When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

***7. Revise what you wrote:*** When you write anything, always read it, summarize it, and then finalize it.

***8. Make every effort:*** Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

***9. Produce good diagrams of your own:*** Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

***10. Use proper verb tense:*** Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

***11. Pick a good study spot:*** Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

***12. Know what you know:*** Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

***13. Use good grammar:*** Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

***14. Arrangement of information:*** Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

***15. Never start at the last minute:*** Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

***16. Multitasking in research is not good:*** Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

***17. Never copy others' work:*** Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

***18. Go to seminars:*** Attend seminars if the topic is relevant to your research area. Utilize all your resources.

***19. Refresh your mind after intervals:*** Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

***20. Think technically:*** Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

***21. Adding unnecessary information:*** Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

***22. Report concluded results:*** Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

***23. Upon conclusion:*** Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

## Informal Guidelines of Research Paper Writing

***Key points to remember:***

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

**Final points:**

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

*The introduction:* This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

**The discussion section:**

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

**General style:**

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

**To make a paper clear:** Adhere to recommended page limits.

*Mistakes to avoid:*

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

**Title page:**

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

**Abstract:** This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

*Reason for writing the article—theory, overall issue, purpose.*

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

**Approach:**

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

**Introduction:**

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

*The following approach can create a valuable beginning:*

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

**Approach:**

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

**Procedures (methods and materials):**

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

**Materials:**

*Materials may be reported in part of a section or else they may be recognized along with your measures.*

**Methods:**

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

**Approach:**

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

**What to keep away from:**

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

**Results:**

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

**Content:**

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

**What to stay away from:**

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

**Approach:**

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

**Figures and tables:**

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

**Discussion:**

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

**Approach:**

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

## The Administration Rules

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

*Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection*.

*Segment draft and final research paper:* You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

*Written material:* You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.

## Criterion for Grading a Research Paper (Compilation) by Global Journals

**Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals.**

| Topics | Grades | | |
|---|---|---|---|
| | **A-B** | **C-D** | **E-F** |
| ***Abstract*** | Clear and concise with appropriate content, Correct format. 200 words or below | Unclear summary and no specific data, Incorrect form Above 200 words | No specific data with ambiguous information<br>Above 250 words |
| ***Introduction*** | Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited | Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter | Out of place depth and content, hazy format |
| ***Methods and Procedures*** | Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads | Difficult to comprehend with embarrassed text, too much explanation but completed | Incorrect and unorganized structure with hazy meaning |
| ***Result*** | Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake | Complete and embarrassed text, difficult to comprehend | Irregular format with wrong facts and figures |
| ***Discussion*** | Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited | Wordy, unclear conclusion, spurious | Conclusion is not cited, unorganized, difficult to comprehend |
| ***References*** | Complete and correct format, well organized | Beside the point, Incomplete | Wrong format and structuring |

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