5.0 DISCUSSION

Table 5.1: Summary of all the findings of all the specimen

Specimen and Disc level	NP impression on AF	Facet joint degeneration		Pannus	Micro	X-Ray	Correlation	Comment
		LEFT	RIGHT					
A L1/2							0	No correlation
L 2/3	L	3X		R		L	3	Correlates
L 3/4						R	0	No correlation
L 4/5			X				0	No correlation
L5 / S1	L	X				L	3	Correlates
B L1/2	L	3X		L		L+R	3	Correlates
L 2/3	R		2X		R		3	Correlates
L 3/4				L			0	No correlation
L 4/5	R	X	2X	L		L	2	Correlates-mixed
L5 / S1		X	2X			L+R	2	No correlation
C L1/2	L+R	X	3X				2	Correlates
L 2/3		X	2X	L			0	No correlation
L 3/4	L+R	2X	2X			Post	2	Correlates-mixed
L 4/5	L	5X	3X		L	L	4	Correlates
L5 / S1	POOR DEFINITION	5X	4X			L	3	Correlates
D L1/2			X	L+R			0	No correlation
L 2/3		X	2X			L	2	Correlates
L 3/4	R	X	3X	L		R	3	Correlates
L 4/5		3X	3X	L+R			0	No correlation
L5 / S1	R	5X	4X		R	R	4	Correlates
E L1/2	L+R	5X	2X	R		L+R	3	Correlates-mixed
L 2/3	L+R	3X	2X	L		L	3	Correlates-mixed
L 3/4		2X	3X	R			0	No correlation
L 4/5	L	5X	4X			L	3	Correlates
L5 / S1	L	5X	3X			Post	3	Correlates

Table 5.1shows a summary of findings reported on at the end of each sub section in the results chapter.

The summary table 5.1 has 7 columns. There are 5 columns representing the areas of reporting. The 7th column indicates whether the findings “correlate” i.e. support the hypothesis, are “mixed” indicating a bi lateral finding which may be 50% positive, or “no correlation” indicating it does not support the hypothesis.

Column A – Nucleus pulposus impression on the anulus fibrosus. Macroscopic examination of the exposed two halves of the intervertebral disc showing the nucleus pulposus in relation to the anulus fibrosus.

Column B – Macroscopic evaluation of the hyaline cartilage surface of the articulating facet joint and recording the extent of degeneration.

Column C – The presence of a pannus formation in the facet joint.

Column D – Microscopic examination of tissue samples of the anulus fibrosus.

Column E – Evaluation of the intact disc by injecting a radio opaque dye, under pressure, into the nucleus pulposus and recording the dye migration by X ray.

Column F – Shows numerically how many columns correlated with the hypothesis.

0 -1	No correlation
2	Two columns with a similar recording was the minimum criteria for correlation.
3	Three columns indicated a strong support for the hypothesis.
4	Four columns indicated a very positive support for the hypothesis

Column G – Indicates whether there is correlation, mixed correlation or no correlation.

Legend for summary table

L= Left
R = Right
X = < 15% degeneration
2X = 15-25% degeneration
3X = 25-40% degeneration
4X = 40-50% degeneration
5X = 50% + degeneration

In the literature review, an attempt was made to show the input of various authors and researchers regarding the matter of immobilization and the subsequent degenerative changes in the structure of the intervertebral disc and the apophyseal articulations.

With regard to the hypothesis of this study, it was important to show that:

1) Facet degeneration occurred with ipsilateral failure of the anulus fibrosus in the form of fissuring.
2) A perceivable degenerative change in the facet joint could be observed before annular changes were observed.

Vertebrae move in translation and rotation about a three coordinate axis. Motion is initiated and guided by a balance between gravity, muscle action and joint geometrics. Physiological movement is limited by ligaments and the plane of the facet joints.

When the loads become excessive, damage to the disc, facets, ligaments and muscles will occur. (Triano 1980)

Normal nutrition of the intervertebral disc has already been pointed out and this undoubtedly, is facilitated by movement in the three joint complex consisting of the intervertebral disc and the facet joints. Compressive and decompressive loading occurs primarily at discal level, whilst rotatory gliding movement occurs at the facet joint level.

The literature also shows that <u>lack</u> of movement results in progressive degenerative changes of the articular structures. This in turn results in decreasing nutrition of the components of the intervertebral disc.

The hypothesis of this work is that damage to, or degeneration of a facet joint, results in ipsilateral damage or degeneration of the anulus fibrosus. This in turn may result in the formation of an ipsilateral rent or fissure in the anulus. If the rent is wide enough to allow passage of the nucleus pulposus material, it may enter into and protrude through the fissure in the annulus (A study of this process is discussed by the author in the annexure).

In the x-ray study, the dye infiltration into the nucleus pulposus revealed that sometimes the nucleus had a “double” appearance, meaning it had a upper and lower portion. The significance of this is also taken up in the annexure. This double form could have had an influence on the reporting of findings as the dissection could well have missed the fissure.

Unless originated by an acute excessive axial loading force, anular lesions are the result of a degenerative process associated to a “malnourished” structure.

The critical question then arises as to how to discover “how and when” an anulus is degenerated or fissured. The experimental work in this thesis has indicated a degree of correlation between the appearances of the structures in the intervertebral disc and arthritic degeneration in the facet joints.

The interior of the structures of the three-joint-complex was studied to determine the presence of alteration of structure of the intra-articular structures of the articulations. The intervertebral discs were injected with a radio opaque dye into the nucleus pulposus to observe the migration of dye with the purpose of identifying anular weakening. Some of the discs indicated movement of the dye towards the posterior periphery of the annuls, suggesting migration of the nuclear material. In some discs there appeared to be a fragmentation in the transitional zone between the nucleus and the anulus.

In some cases the dye entered a "gap" which normally would be the position of the end plate of the vertebral body, suggesting end-plate and not anular degeneration. (See annexure)

While attempts were made to study both the facet joints and the intervertebral discs microscopically, the results were generally poor. The probable cause of this was poor fixation of these structures in the cadaver material and the thinness of the hyaline cartilage and undulating surface of the facet surface.

However, the few slides that could be produced, did give some correlative information in relation to the hypothesis. Again, even if good slides were produced, the findings could have been obscured by the "double-nucleus" phenomenon, in that the transverse dissection could have missed the rent or fissure. In future studies, the migration of dye must be considered when dissecting the disc.

The tensile and compressive forces acting on the anulus altering the axial height are important in the nutrition of the anulus fibrosus and the nucleus pulposus via the process of imbibition,or grawing up of fluid and osmosis.

Damant et al (1968) suggests that intra discal nutritional deficiencies could lead to disc degeneration.

In a study by Urban et al (1978) on anaesthetised dogs, they found that diffusion (by imbibing and osmosis - Author) appears to be the maim mechanism by which small solutes are transported to and from the disc. Diffusion was found to be enhanced by movement. These findings suggest that intra discal solutes transport is enhanced predominantly by passive diffusion or osmosis. However on the periphery the solute exchange is enhanced by active diffusion when considering that the bone-disc interface at the periphery is only partially permeable, should the end plate route become impaired, there would be a build up of waste products and a resultant nutritional deficiency. This would lead to degenerative changes in the affected structures.

This study on nutrition of the intervertebral disc was very comprehensive and forms a sound basis for understanding disc nutrition and the possibility of physiological disc degeneration.(see annexure)

Chronic overloading of the articular cartilage of the facet joints may encourage the development of osteoarthritis. (Adams and Hutton 1980)

Such changes in the facet joints have been reported in the absence of disc degeneration. Lewin (1964). It therefore cannot be assumed that the zygapophyseal joint degeneration was always secondary to disc degeneration

In summarising the results of their study, Adams and Hutton (1980), stated that disc narrowing (not degeneration- author) showed abnormally high loading of the facet joints, which in turn exhibited gross osteoarthritic changes. In the present study, cases of facet degeneration were observed in the absence of alteration in disc structures

Cramer et al (2004) in the study on 85 laboratory rats put forward the following questions:

A) If fixation would produce degenerative changes in the three joint complex. i.e. spurring of the intervertebral bodies and articular processes, disc thinning and articular cartilage and subchondral articular surface changes.

B) Do the degenerative changes increase over time?

C) Is there a time window with in which these degenerative changes will spontaneously remit if the experimental fixation is removed?

The results of their study showed that degenerative changes occur in hypomobility of the facet joints in the rat model. That the severity of degeneration is time dependant with osteophytic formation in the period of 4 to 8 weeks.

Restoration of movement in the 1 to 4 week period showed renewal in the articular surface of the facet joints. In the period of 12 weeks, minimal changes were observed in the intervertebral disc. It is important to note that the authors state that this model created hypomobility and not true fixation or fusion. There was thus slight movement in the articular facets but more movement was subjectively observed in the intervertebral disc. The disc was thus able to maintain a degree of nourishment. This is an example of physiological disc narrowing. (see annexure)

Note: In the study below, the term correlation is not used in its statistical connotation, but rather to infer a “bringing together of” all of the tables of findings.

Of the 25 intervertebral discs that were selected and the 100 a joining juxta opposing facet joints, the following summary was made:

2 columns	6 of 18 thus 34%
3 columns	10 of 18, thus 55%
4 columns	2 of 18, thus 11%

From table

No correlation	9 – 36%
Mixed correlation	4 – 16%
Correlates	12 – 48%

When considering the above, 48% shows a positive support for the hypothesis in that facet degeneration and ipsilateral annular fissuring or degeneration is observed together. When the percentiles of mixed findings are added, the figure increases up to 64%.

36% showed no correlation.

13 of the 50 pairs of the (23%) had the presence of a pannus formation, of this 23%, only in 3 cases, was the pannus not associated with a degree of facet degeneration. This finding coincides with the findings of Giles 1988 in that the pannus is observed in cases of facet degeneration. The pannus however was also seen in models where the degenerative process was not evident in this study as stated above. It would therefore appear that the pannus is a variable inclusion in the facet joint.

Comment:
The findings of Cramer et al (2004) and Lantz (1988) are very significant indicating that both narrowing and degeneration are long term features of intervertebral disc lesions and that facet lesions are in existence, with limitation in joint end range motion prevalent before disc lesions are observed.

In this current study, it was observed that 64% of cases of facet degeneration were accompanied by annular degenerative changes, of which 48% was ipsilateral, as compared to 36% where no association could be made.