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RESEARCH ARTICLE

CLINICAL EVALUATION OF KNEE JOINT DISEASES BY SYNOVIAL FLUID ANALYSIS AND SYNOVIAL BIOPSY

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Abstract

This prospective research assessed synovial fluid analysis and synovial biopsy in 50 individuals with knee joint oedema to facilitate the identification of several arthropathies. Patients aged 27 to 70 years had thorough evaluations, including morphological, microscopic, microbiological, and biochemical studies of synovial fluid, supplemented by radiographic imaging and, in certain instances, synovial biopsies. The prevalence of knee joint illnesses indicated that osteoarthritis (OA), rheumatoid arthritis (RA), and inflammatory arthritis–NOS each represented 18% of cases, whereas noninflammatory arthritis–NOS constituted 16%, and traumatic arthritis was noted in 10%. Septic arthritis, tuberculous arthritis, and pigmented villonodular synovitis (PVNS) occurred in 4% of cases each, while gout was present in 2% and non-diagnostic aspirates were observed in 6% of cases. The properties of synovial fluid differed throughout the situations. Osteoarthritis (OA) often presented with transparent fluid of normal viscosity and low leukocyte counts, aligning with degenerative joint alterations, but rheumatoid arthritis (RA) patients primarily displayed opaque, low-viscosity fluid with significantly higher leukocyte counts and fragile mucin clots, signifying severe inflammation. The radiographic findings corroborated these diagnoses, with osteoarthritis exhibiting characteristics such as sclerosis, subchondral cysts, and joint space constriction, whereas rheumatoid arthritis revealed deformities and decreased lateral joint space. Findings from the synovial biopsy, such as synovial hyperplasia, lymphoid follicles, and granulomatous inflammation, provide further diagnostic validation. The study emphasises that synovial fluid analysis, in conjunction with imaging and histological assessment, is crucial for distinguishing knee joint disorders and informing suitable therapeutic therapy. Limitations encompass the limited sample size, variability of underlying diseases, and sporadic non-diagnostic samples. Implement extensive, multicenter randomised controlled studies to corroborate these results. Investigate the adjustment of dosages for buprenorphine and fentanyl to achieve a balance between effectiveness and adverse effects. Assess patient satisfaction, opioid-associated adverse effects, and long-term recovery results in subsequent studies.

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Introduction:-

Synovial fluid is a plasma transudate derived from synovial capillaries, altered by the secretory functions of type B synovial lining cells. Synovial fluid is essential for adequate lubrication and operation of the joints. The characteristic of synovial fluid is ascribed to the amount of the hyaluronic acid-protein complex (mucin). Synovial fluid analysis is a straightforward approach that involves the macroscopic, microscopic, and microbiological examination of synovial fluid to discriminate various arthritic diseases. This study may assist in diagnosing a wide range of disorders, including septic arthritis, tuberculosis arthritis, rheumatoid arthritis, and periprosthetic joint infections. Synovial biopsies are generally performed to diagnose joint diseases. Analysing synovial fluid is a valuable test that a physician may conduct to assess a patient with joint illness. (1,2)

Aims & Objectives of the Study:-

To evaluate the contribution of various cytomorphologic features of synovial fluid with additional microbiological, immunological, biochemical and culture studies in the diagnosis of various arthropathies.

To analyse the gross, microscopic, microbiological and biochemical variations in the synovial fluid in different cases of knee joint effusion.

Materials and Methods:-**Detailed research plans:**

We executed a prospective investigation for a duration of two years. This study will be undertaken at Dr. PSIMS & RF Hospital from November 2020 to October 2022, involving a sample size of 50 patients with knee joint effusion who will be enrolled after obtaining their informed written permission.

Method of Collecting Data:-

Individuals with knee joint oedema will be included in the trial. Patient details were collected based on age, sex, and duration, including any history of joint steroid injections, trauma, and previous knee joint aspirations, along with any laboratory investigations as required.



Fig 1:- Showing Right knee joint swelling.

Sample Collection:

Sterile, disposable needles and plastic syringes were employed to collect synovial fluids, therefore preventing the contamination of the fluids with birefringent particles. Heparin, oxalate, and powdered EDTA

anticoagulants were excluded due to their propensity to create crystalline artefacts that might lead to misinterpretation during joint aspiration.



Fig 2:- Knee joint Aspiration for SF Analysis.

Results:-

This study investigated 50 synovial fluid samples from individuals with knee joint swelling to evaluate demographic factors, joint involvement, and laboratory and radiographic findings across different arthropathies. The research population varied in age from 27 to 70 years. A 27-year-old female with rheumatoid arthritis (RA) and a 70-year-old female with osteoarthritis (OA) exemplified the age spectrum, illustrating the conventional demographic distribution of both disorders. The majority of patients (43/50) exhibited unilateral joint involvement, with the knee being the only joint aspirated; the duration of joint oedema ranged from one week to seven years. All patients presented with knee effusion; 19 displayed abnormalities, and 26 reported discomforts accompanied by reduced mobility. Radiographically, osteoarthritis (OA) was identified by sclerosis, subchondral cysts, and narrowing of the joint space, whereas rheumatoid arthritis (RA) exhibited subchondral cysts, deformity, and a decrease in lateral joint space. Post-traumatic arthritis was linked to malunited fractures.

Table 1:-

Serial.No	Disease	No. of SF	%
1	OA	09	18
2	RA	09	18
3	TA (traumatic arthritis)	05	10
4	SA (septic arthritis)	02	04
5	TB arthritis	02	04
6	Gout	01	02
7	PVNS	02	04
8	IA-NOS	09	18
9	NIA-NOS	08	16
10	NDA	03	06

The table summarises 50 synovial fluid samples, illustrating the distribution of diseases by quantity and percentage.

Osteoarthritis, Rheumatoid Arthritis, and Inflammatory Arthritis–NOS each represent 18%, whilst NonInflammatory Arthritis–NOS constitutes 16% and Traumatic Arthritis accounts for 10%. Septic Arthritis, Tuberculosis Arthritis, and PVNS each account for 4%, Gout for 2%, and Non-Diagnostic Aspirates for 6%, reflecting a variety of knee joint diseases.

Table 2:-

SerialNo	Nature of Diseases	Clear	Opaque
1	OA	08	01
2	RA	01	08
3	TA	-	05
4	SA	01	01
5	TB arthritis	-	02
6	Gout	-	01
7	PVNS	-	02
8	IA-NOS	-	09
9	NIA-NOS	06	02
10	NDA	-	03

The table indicates that OA samples were primarily clear (8 clear, 1 opaque), whereas RA, TA, TB arthritis, PVNS,

IA NOS, and NDA generally had opaque fluid. RA exhibited 1 clear sample compared to 8 opaque samples, while TA, TB arthritis, Gout, and NDA presented solely opaque findings. Conversely, NIA NOS exhibited a combination of 6 transparent and 2 opaque samples, underscoring the heterogeneity in synovial fluid clarity among different illnesses.

Table 3:-

S. No	Type of Diseases	Normal	Low
1	OA	09	-
2	RA	01	08
3	TA	05	-
4	SA	01	01
5	TB arthritis	-	02
6	Gout	-	01
7	PVNS	-	02
8	IA-NOS	-	09
9	NIA-NOS	06	02
10	NDA	-	02

Table-3 presents an examination of synovial fluid viscosity across different knee joint pathologies. Osteoarthritis instances have normal viscosity, however rheumatoid arthritis and other inflammatory disorders typically demonstrate poor viscosity. Cases of traumatic arthritis have normal viscosity, but septic arthritis and TB arthritis yield variable findings.

Table 4:-

S. No	Type of Disease	TLC cells/cumm	Mean-cells/cumm
1	OA	150 - 800	384
2	RA	7000 – 18,500	12,178
3	SA	50,000– 62,000	56,000
4	TB arthritis	3800 – 8,000	5,900
5	Gout	4500	-
6	TA	2200 – 4650	3370
7	PVNS	3600–4200	3750
8	Inflammatory Arthritis–NOS	2200–12,500	4256

9	Non-Inflammatory Arthritis–NOS	200 – 700	444
10	NDA	--	--

Table 4 presents the total leukocyte counts (TLC) across various knee joint disorders. Septic arthritis has the greatest mean total leukocyte count (TLC) at 56,000 cells/cubic millimetre, followed by rheumatoid arthritis with a mean TLC of 12,178 cells/cubic millimetre. Osteoarthritis exhibits the lowest mean total leukocyte count at 384 cells/cumm.

The study of synovial fluid indicated that the aspirated volume varied between 2 and 8 cc, with the predominant outcome (38 instances) being straw-yellow fluid. The fluid clarity was mostly opaque in 34 instances, and the viscosity was typically low in 28 cases, in contrast to normal levels seen in 22 cases. Differential leukocyte counts differed by disease: OA patients had low cell counts (mean 384 cells/cumm) with lymphocytic predominance, whereas RA samples showed significantly higher counts (mean 12,178 cells/cumm) with a high percentage of neutrophils. Additional disease-specific observations were hemorrhagic effusion in traumatic arthritis, the detection of monosodium urate crystals in gout, and distinctive cellular profiles in tuberculous arthritis and pigmented villonodular synovitis (PVNS). In a subgroup of patients, synovial biopsy further corroborated the diagnosis of osteoarthritis, rheumatoid arthritis, tuberculous arthritis, septic arthritis, and pigmented villonodular synovitis.

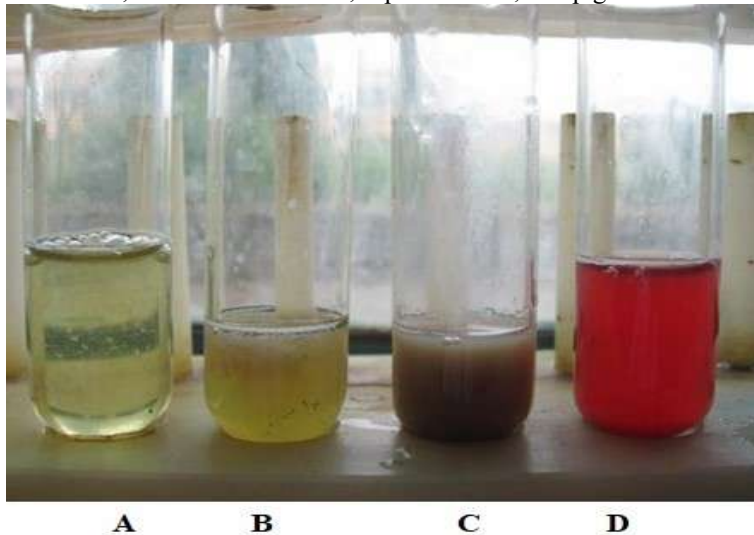


Figure 1:- Synovial Fluid of different diseases affecting knee joint.

Sample A: clear, straw yellow colour – OA

Sample B: opaque, yellow– RA

Sample C: opaque – SA

Sample D: Trauma–hemorrhagic

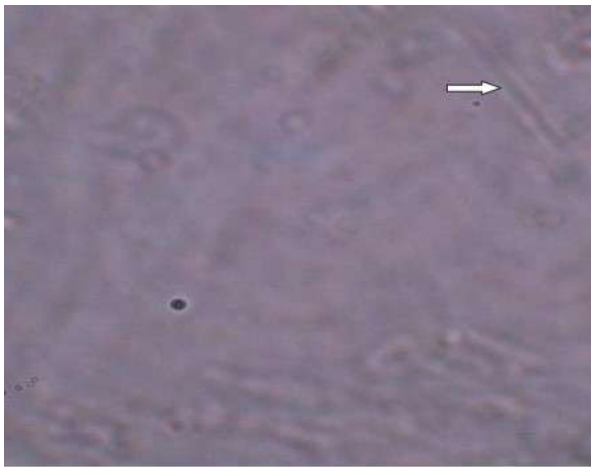


Figure 2:- Arrow mark representing cartilage fibrils in OA case on Wet mount examination.(x40).

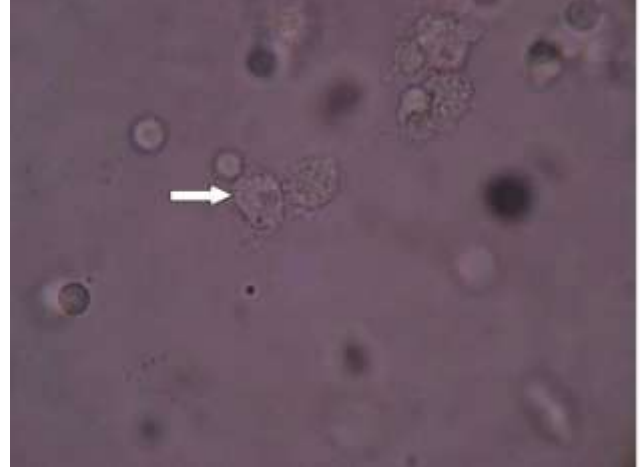


Fig. No.3:- Arrow representing ragocytes in RA on Wet mount preparation (x10).

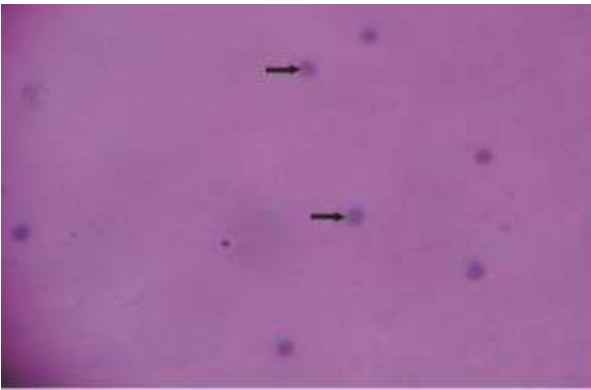


Figure 4:- Arrow mark representing lymphocytes in OA case.

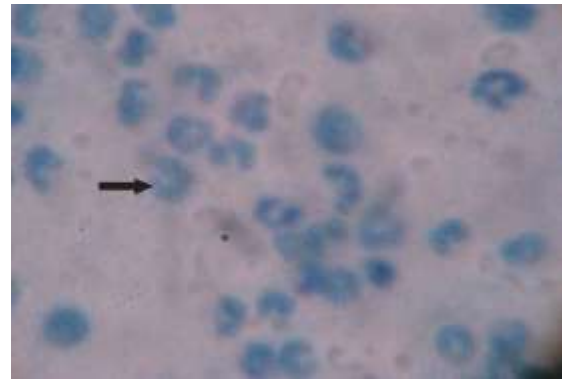


Fig. No.5:- Arrow representing neutrophils (N) in RA case.(papstainx40).

Discussion:-

This study assessed 50 synovial fluid samples from patients aged 27 to 70 with knee joint involvement, diagnosing a range of arthropathies including osteoarthritis (OA), rheumatoid arthritis (RA), traumatic arthritis (TA), septic arthritis (SA), tuberculous arthritis, gout, pigmented villonodular synovitis (PVNS), inflammatory arthritis–NOS, non-inflammatory arthritis–NOS, and non-diagnostic aspirates. OA, RA, and inflammatory arthritis–NOS each constituted 18% of cases, whereas non-inflammatory arthritis–NOS comprised 16%, underscoring the prevalence of inflammatory disorders. The results indicated that osteoarthritis patients, often older with an average age of 62.6 years, displayed transparent synovial fluid with normal viscosity, a robust mucus clot test, and low total leukocyte counts, aligning with the degenerative characteristics of the condition. Conversely, RA patients exhibited mostly turbid, low-viscosity fluid with elevated leukocyte counts (mean 12,178 cells/cumm) and a fragile mucin clot, supporting prior findings that highlight the vigorous inflammatory response in RA. (3-5)

Joint involvement was predominantly unilateral (43 out of 50 cases), with bilateral involvement observed in 7 instances, and all patients had knee joint effusion. The radiographic findings corroborated the synovial fluid analysis: osteoarthritis was linked to sclerosis, subchondral cysts, and joint space constriction, whereas rheumatoid arthritis exhibited subchondral cysts, deformities, and a decrease in lateral joint space. Cases of traumatic arthritis exhibit an average aspirated fluid volume of 6 ml and a hemorrhagic appearance, accompanied by malunited fractures, consistent with literature detailing post-traumatic joint alterations. Likewise, instances of septic arthritis demonstrated markedly elevated cell counts (mean 56,000 cells/cumm) and presented with both clear and opaque fluid, consistent with other investigations indicating significant inflammatory cell infiltration in infectious arthritis.

Moreover, specialised discoveries, such the detection of monosodium urate crystals in gout and the unique pigmented and friable characteristics noted in PVNS, augment the diagnostic specificity of synovial fluid analysis. In specific instances, synovial biopsy yielded histopathological confirmation, revealing synovial hyperplasia, lymphoid follicles, and perivascular mononuclear infiltrates in rheumatoid arthritis biopsies, whereas tuberculous arthritis exhibited granulomatous inflammation with caseous necrosis and Langerhans giant cells—observations thoroughly documented in the literature. (6-8)

These findings align with prior research that highlights the significance of synovial fluid properties—such as volume, clarity, viscosity, mucus clot formation, and total leukocyte count—in distinguishing degenerative, inflammatory, and infectious joint disorders. The research underscores that synovial fluid analysis, in conjunction with imaging and histology, is essential for the precise diagnosis and treatment of knee joint arthropathies.

Limitations:-

The sample size was limited to 50 cases, perhaps affecting the generalisability of the findings. The heterogeneity of underlying conditions and the variable duration of joint oedema may result in differences in synovial fluid characteristics. A segment of the aspirates was non-diagnostic, reducing the comprehensiveness of the investigation. The study's cross-sectional design and single-center setting limit the assessment of longitudinal changes and external validity. Thorough quantitative assessments (e.g., precise cell counts in non-diagnostic specimens) were hindered by delays in sample processing.

Conclusion:-

The study emphasises that knee joint oedema in patients typically results from isolated joint involvement, with specific synovial fluid properties that facilitate the differentiation of arthropathies. Osteoarthritis and rheumatoid arthritis exhibit distinct characteristics in fluid clarity, viscosity, and leukocyte composition that align with their radiographic and clinical presentations. The findings indicate that synovial fluid analysis, together with imaging and histology, is an essential tool in diagnosing knee joint disorders and can inform suitable therapeutic methods.

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