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Research Article

AN OBSERVATIONAL STUDY FOR THE CLINICAL CORRELATION OF *SAMA-SNAYUGATA VATA* (NON-SPECIFIC CHRONIC SYNOVITIS) WITH THE ANALYSIS OF THE SYNOVIAL FLUID

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ABSTRACT

This study delves into the intricate interplay between the Ayurvedic concept of *Sama-Snayugata Vata*, characterized by the vitiation of *Vata dosha* affecting the musculoskeletal system, and the analysis of synovial fluid in the context of knee effusion. Synovial fluid, a crucial component within diarthrodial joints, serves to nourish, lubricate, and protect the joint structures. Under normal circumstances, its biochemical composition closely mirrors that of plasma. However, pathological conditions, such as arthritis, can lead to alterations in its constituents, offering insights into underlying joint pathology. Central to this study is the Ayurvedic concept of *Shleshmadhara Kala*, representing a phase characterized by optimal nourishment and lubrication of bodily tissues, essential for joint health and functionality. The *Janu Sandhi*, or knee joint, exemplifies this interplay, where the integrity of tendons and ligaments (*Snayu*) is crucial. Conditions like knee effusion, marked by abnormal synovial fluid accumulation, disrupt this equilibrium, leading to clinical manifestations and impairments. This observational study aims to comprehensively explore the correlation between *Shleshmadhara Kala* and the *Snayu* of the *Janu Sandhi* in the pathogenesis of *Sama-Snayugata Vata*, particularly in the context of knee effusion. Insights gained from this research will provide a foundation for devising effective therapeutic strategies, with the goal of restoring *Vata dosha* balance, rejuvenating affected tissues, and ultimately alleviating the manifestations of this condition. This investigation holds promise for enhancing our understanding of non-specific chronic synovitis and refining treatment modalities for improved patient outcomes.

INTRODUCTION

The term "synovial" originates from the Latin word denoting egg or egg white. Synovial fluid, commonly referred to as articulatory fluid, is situated within all diarthrodial joints. Within synovial joints, bones are ensconced in articular cartilage and are demarcated by a minute cavity housing the synovial fluid. Collectively, these anatomical constituents constitute the joint, enveloped by the articular capsule.

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Within these capsules reside specialized secretory cells known as synoviocytes (Type A and B), responsible for generating various components of the synovial fluid, such as matrix constituents, hyaluronic acid and salts, collagens, and fibronectin for the intimal interstitium and synovial fluid[1]. Furthermore, synovial fluid bestows nutrients and lubrication upon the joints. From a biochemical standpoint, synovial fluid represents an ultrafiltrate of plasma across the synovial membrane, enriched with diverse compounds synthesized by the synoviocytes. Under normal physiological circumstances, the biochemical composition of synovial fluid closely mirrors that of plasma. Additionally, synoviocytes play a role in locally producing cytokines, small-molecule inflammation mediators, and proteolytic enzymes that disintegrate the extracellular matrix. Hence, they constitute pivotal

elements within the inflammatory pathways associated with rheumatoid arthritis affecting the joints [2]. The combined action of cartilage and synovial fluid safeguards the bones by mitigating friction during movement. Moreover, synovial fluid affords nutrients and lubrication for the joints. In terms of biochemistry, synovial fluid is an ultrafiltrate of plasma traversing the synovial membrane, augmented with a variety of compounds synthesized by the synoviocytes. Under pathological conditions, the laboratory analysis of synovial fluid furnishes insights into the underlying pathology affecting the joint, such as arthritis [3].

Sama Snayugata Vata is a condition in *Ayurveda* characterized by the vitiation of *Vata dosha*, specifically affecting the musculoskeletal system. It encompasses a spectrum of disorders involving the tendons, ligaments, and joints, leading to various clinical presentations. In this context, an essential aspect to consider is the concept of *Shleshmadhara Kala*, which pertains to the physiological phase of life characterized by optimal nourishment and lubrication of bodily tissues. This phase is crucial for maintaining joint health and functionality. When we focus on the *Janu Sandhi*, or the knee joint, it becomes evident that the integrity of the *Snayu* (tendons and ligaments) in this region plays a pivotal role. The *Janu Sandhi* is particularly susceptible to conditions like knee effusion, where an abnormal accumulation of synovial fluid within the joint space occurs. This condition not only disrupts the equilibrium of *Shleshmadhara Kala* but also directly impacts the Snayu, leading to a range of clinical manifestations and impairments. Understanding the intricate interplay between *Shleshmadhara Kala* and the *Snayu* of the *Janu Sandhi* is essential in comprehending the pathogenesis of *Sama Snayugata Vata*, especially in the context of knee effusion. This correlation forms the basis for devising effective therapeutic strategies that aim to restore the balance of *Vata dosha*, rejuvenate the affected tissues, and ultimately alleviate the manifestations of this condition. In this discourse, we delve into a comprehensive exploration of these interconnected concepts, shedding light on the pathophysiology and treatment modalities for *Sama Snayugata Vata* with a specific focus on knee effusion.

AIMS AND OBJCTIVES

- Analysis of synovial fluid in Knee effusion
- To study the constituents/composition of the synovial fluid in the cases of knee effusion in comparison to its normal composition.

MATERIAL AND METHODS

Study Type

- Analytical Study
- Total 50 patients having knee effusion were selected for the analysis of synovial fluid.
- Arthrocentesis of the affected knee was performed under full aseptic condition taking the supra-lateral approach with patient lying in the supine position as per standard protocol and sent immediately for cytological analysis in EDTA vial.

Study Design

Randomized, Prospective, Uni-centric observational study (Computer generated randomization was followed).

Target Sample Size

50 for the analytical study

Statistical Analysis

The statistical analysis was done using JASP software (version 0.17.3)

Selection Criteria

Inclusion Criteria

- Patients of the age group ranging from 35-65 years for survey and analytical study having knee effusion visited to NIA hospital.
- Patients were selected randomly, irrespective of gender, economical, educational and marital status.

Exclusion Criteria

- Patients suffering from specific variety of knee effusion such as tubercular, specific arthritis, conditions like post traumatic knee hemarthrosis.

Overall Normal Characteristics of Synovial Fluid

Under typical physiological conditions, synovial fluid exhibits specific characteristics. It is typically colorless or possesses a faint yellow hue, and it maintains clarity. This fluid has the capacity to generate viscous strands measuring between 4-6cm, owing to the polymerization process of hyaluronic acid. The standard features of normal synovial fluid encompass:

- Appearance: Transparent
- White Blood Cell (WBC) Count: Below 200 cells/µL
- Polymorphonuclear Neutrophils (PMNs): Less than 25%
- Viscosity: Elevated
- Glucose Level: Comparable to the patient's serum glucose concentration. In pathological conditions, laboratory evaluation of synovial fluid provides information about the pathology of the condition affecting the joint (e.g., arthritis).[3]

Analysis of Synovial Fluid (Indications and result interpretation)

Indications include evaluation of inflammation, infections, trauma, and degenerative diseases of the joints.

Collection and Testing

The biochemical composition and microscopic content of synovial fluid undergo alterations in the presence of various diseases, conditions, or due to medication usage. Arthrocentesis, a needle aspiration procedure, is employed to obtain synovial fluid. The quantity collected is contingent on the joint size and the specific tests required.

Different types of preservatives are necessitated depending on the nature of the test:

- Sterile heparinized tubes for microbiology analysis
- Heparinized (Green-top tubes) or EDTA tubes (Lavender-top tubes) for cell count
- Most chemistry tests do not require preservatives
- NaF is used for glucose testing

Powdered preservatives or gloves should be avoided during sample collection, as they may introduce particulates that could interfere with synovial crystal analysis. Additionally, prompt centrifugation, separation, and sample assessment are recommended to prevent alterations in synovial crystals.

Much like with other bodily fluids, routine laboratory assessment of synovial fluid involves the following three stages:

- Physical examination of synovial fluid, encompassing factors like appearance, including color, viscosity, and other physical attributes.
- Chemical analysis, encompassing assessments such as glucose levels, total protein content, and uric acid levels.
- Microscopic evaluation, involving cell count, differential count, and identification of crystals.

Furthermore, synovial fluid can also undergo microbiologic, serologic, and cytologic laboratory assessments.

Conditions associated with changes in the appearance of synovial fluid

The characteristics of synovial fluid, including its color and transparency, may undergo variations in different medical conditions, as outlined below:

- **Inflammatory diseases of nonimmunologic origin:** The fluid may appear cloudy or turbid, with a dense yellow hue containing crystals.
- **Septic conditions:** The fluid might exhibit a cloudy, yellow-greenish tint, with increased viscosity, and a positive culture indicating the presence of infection.
- **Hemorrhagic conditions (e.g., trauma or traumatic aspiration):** The fluid may appear cloudy with a reddish hue, possessing lower viscosity. The white blood cell count in this scenario is comparable to that of blood.
- **Presence of a high concentration of crystals:** The fluid could manifest as milky or cloudy in appearance.

Furthermore, in cases of arthritis, a reduction in synovial fluid viscosity occurs due to diminished production and polymerization of hyaluronic acid. A tactile method for assessing viscosity involves forming a strand of synovial fluid between the fingertips, with a length of 4-6cm considered normal. While the mucin clot test is available for viscosity evaluation, it provides limited diagnostic information and is seldom utilized in clinical practice. [3,4]

Conditions associated with changes in the biochemical composition of synovial fluid

For a precise analysis of synovial fluid laboratory findings, it is imperative to concurrently assess serum samples. Under normal circumstances, the biochemical composition of synovial fluid closely mirrors that of serum. Consequently, the concentration of most analytes in synovial fluid corresponds to that in serum.

Glucose

Glucose levels in synovial fluid are routinely examined, and they should align with those in serum for accurate interpretation. Notably, glucose experiences a significant reduction in inflammatory conditions, such as immunologic disorders, lupus, scleroderma, ankylosis, crystal-induced gout and pseudogout, as well as rheumatoid arthritis, and in septic joint diseases. To obviate the potential of obtaining a falsely diminished glucose concentration, it is essential to collect samples for glucose assessment in NaF tubes. This precautionary measure hinders swift glycolysis and ensures that the evaluation is conducted within one hour of collection. [3,4]

Total Protein

The total protein concentration in synovial fluid typically registers at a lower level compared to that found in serum, often amounting to roughly one-third of the serum levels. An abnormality is noted when synovial fluid protein levels exceed 2.5g/dl, with concentrations surpassing 4.5g/dl indicating a substantial degree of inflammation. It is worth noting that this concentration tends to escalate in cases of both inflammatory and hemorrhagic disorders. [3,4]

Albumin

The normal albumin level in synovial fluid is one third of the protein levels. Low albumin levels

indicate the severity of inflammation and can hinder the effectiveness of medical and surgical treatments, reducing overall well-being and lifespan. In critical illness, changes in albumin levels and body water content (weight loss or gain) are important indicators of health improvement or deterioration. It's unlikely that low albumin levels indicate a true deficiency, so administering albumin through infusion is unlikely to be helpful. Addressing the underlying inflammatory cause should be the main focus of treatment, although many individuals with low albumin levels may also be malnourished and require nutritional support. While nutrition may not be immediately beneficial in the early proinflammatory stages of trauma or critical illness, further research is needed in this area. [7]

Cell counts in synovial fluid [6]

White blood cell (WBC) count stands as one of the most commonly conducted tests on synovial fluid. In standard conditions, the synovial fluid typically hosts fewer than 200 cells per microliter (μL). However, this count experiences a notable surge in cases of inflammation and infection. To discern between various conditions, Gram staining and culture analysis can be employed for a more specific diagnosis.

In accordance with the guidelines established by the American Rheumatologic Association, the classification based on WBC count is as follows:

- Non-inflammatory: Ranging from less than 200 to 2000 WBC per cubic millimeter (mm^3)
- Inflammatory: Falling between more than 2000 to 50,000 WBC per mm^3
- Infectious: Exceeding 50,000 WBC per mm^3

Differential with polymorphic nuclear cells (PMNs)

If PMNs constitute over 75 percent of the cell population, it suggests a potential bacterial joint infection.

Sama Snayugata Vata

The present state of affairs can be elucidated in a more comprehensive manner through the following scientific exposition. The concatenation of causal factors, referred to as *Nidanas*; namely *Jara* (senescence), *Ativyayama* (excessive physical strain), *Atisankshobha* (excessive mental agitation), *Ativighattana* of *Asthi* (excessive impact on bone due to repeated trivial trauma), and *Vatalahara sevanam* (consumption of foods exacerbating *Vata dosha*), leads to derangement of *Asthivaha srotas* (channel responsible for bone health), *Agni vaishamya* (imbalance in metabolic fire), *Vyanavata kopa* (aggravation of *Vata dosha*), and *Kapha kshaya* (diminished *Kapha dosha*).[8] The scenario of *Vishamagni* (aberrant digestive fire) settled due to the intake of *Vatala ahara* (foods causing *Vata* imbalance) and *Vihara* (lifestyle), culminates in the formation of *Ama* (undigested metabolic by products). This, in turn, gives rise to *Srotovrodha* (obstruction of channels), subsequently instigating *Dhatukshaya* (depletion of bodily tissues). The vitiated *Vyana Vayu* (subtype of *Vata* responsible for circulation) traverses throughout the physiological system via various *Srotases* (channels) and *Sandhis* (junctions). Eventually, this vitiated *Vayu* localizes within the *Janu sandhi* (knee joint), a site housing *Sleshaka kapha* (lubricating bodily fluid) in conjunction with improperly formed *Dhatus* (tissues). [9] Within this *Sandhi*, the pre-existing *Srotovaigunya* (weakened channels) provide ample space for the lodging of *Kupita* (aggravated) *Vata Dosha*, thus facilitating the expression of its perturbed characteristics. The inherent dryness, roughness, and lightness of *Vata Dosha* inflict afflictions upon the *Sandhi*. The *Sleshaka Kapha*, usually contributing to joint function with qualities such as lubrication, heaviness, and viscosity, undergoes a reduction in these attributes due to the influence of the *Vata Dosha* within the *Sandhi*. Consequently, movements become agonizing in affected individuals. This sequence of events leads to an escalated production of *Malarupa* (abnormal growth) within the *Asthi* (bone) and results in the depletion of *Majja Dhatu*. This cascade materializes as the emergence of *Adhyasthi utpatti* (formation of bone spurs), *Asthisoushiryam* (osteoporosis), *Asthishula* (bone pain), and *Asthibheda* (bone fractures). Concurrently, the exacerbated *Vata Dosha*, infiltrating the *Kapha sthana* (site of *Kapha*) within the *Sandhi*, encounters impediments posed by *Kapha*. The obstructed *Vata* engenders the development of *Sopha* (swelling) and *Soola* (pain) therein. This further leads to restricted joint movements and stiffness in the affected knee joint. The synergy between *Ama* engendered by *Vishamagni* and aggravated *Vata* engenders the manifestation of *Sama vata* (morbid *Vata*). This subsequently gave rise to the manifestation of systemic symptoms, including *Balbhransha, Alasya, Aruchi, Guruta, Apakti, Antrakunjan,* and *Vibandha* [10].

In the present study, the 50 subjects having an abnormal accumulation of fluid in the knee occurring secondary to chronic synovitis were selected for the analysis of the synovial fluid on the pre-decided parameters. The majority of the cases were having osteoarthrosis associated with chronic synovitis of the knee capsule.

Table 1: Synovial fluid analysis of 50 patients

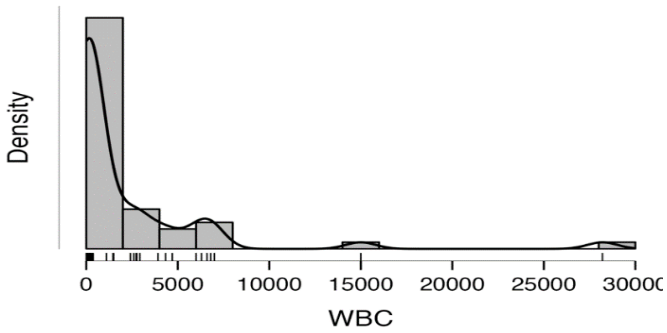
S.No.	WBC	RBC	Poly	Lympho	Total Protein	Albumin	Glucose
1.	2413	0	93	5	3800	2900	145.8
2.	2598	0	98	2	3800	2900	148.5
3.	4336	0	25	75	3800	3000	77.6
4.	1100	0	70	30	4400	2200	10
5.	6298	0	70	30	5410	2210	182
6.	2727	0	95	5	3800	3000	146
7.	2761	0	95	3	3800	3000	146.5
8.	6600	0	60	40	5100	3000	71.6
9.	166	0	15	85	3200	2200	89.1
10.	7000	0	62	38	5000	2900	67
11.	350	0	60	40	3800	2880	67
12.	3917	0	85	15	3220	1680	290
13.	2932	0	25	75	2300	1800	101.4
14.	4700	0	15	85	5220	1880	47.62
15.	230	0	15	85	3000	2210	118
16.	200	0	10	90	3100	2190	119
17.	280	0	14	86	3200	2200	119
18.	1500	0	60	40	3600	1890	86.6
19.	20	0	30	70	200	190	11
20.	20	0	5	95	200	120	10
21.	30	0	10	90	200	90	14
22.	30	0	30	70	300	140	10
23.	10	0	30	70	300	270	29
24.	10	0	45	55	1900	1490	80
25.	20	0	20	80	1150	900	50
26.	200	0	30	70	1500	990	48
27.	40	0	40	60	1600	950	30
28.	10	0	65	35	1900	1540	79
29.	100	0	60	40	900	200	13
30.	20	0	10	90	2600	1840	80
31.	40	0	40	60	2200	1670	88
32.	20	0	10	90	4600	3720	158
33.	25	0	20	80	4900	3870	173
34.	150	0	6	94	700	370	18
35.	200	0	8	92	3400	2190	74
36.	28200	0	85	15	5600	2720	23
37.	250	0	13	87	3400	2000	180
38.	1460	0	5	95	2400	1710	120
39.	25	0	10	90	3500	2180	92

40.	20	0	40	60	2800	1150	68
41.	200	0	20	80	2600	1880	113.5
42.	50	0	5	95	700	500	10
43.	200	0	30	70	2000	860	59
44.	380	0	20	80	3400	2300	105.5
45.	200	0	20	80	5700	3120	78
46.	50	0	20	80	800	580	41
47.	350	0	10	90	10030	6660	426.6
48.	6800	0	40	60	5200	3060	10
49.	6000	0	85	15	5200	3050	10
50.	15000	0	60	40	4100	2570	61.4

RESULTS

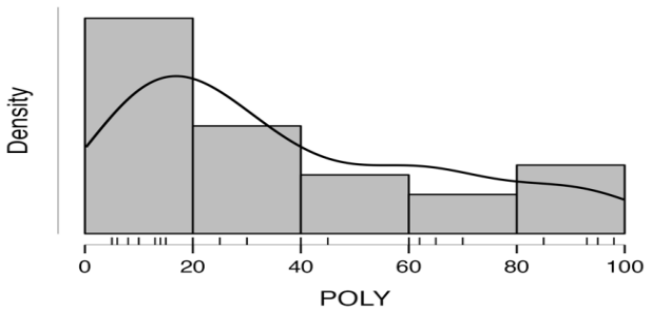
1. WBC

	WBC
Valid	50
Mean	2204.760
Std. Deviation	4717.764
Coefficient of variation	2.140
Minimum	10.000
Maximum	28200.000



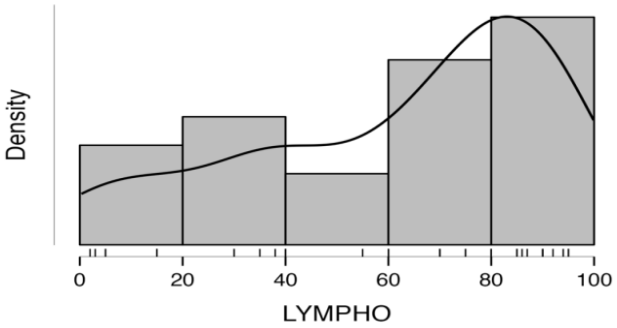
2. Neutrophils

	POLY
Valid	50
Mean	37.780
Std. Deviation	28.881
Coefficient of variation	0.764
Minimum	5.000
Maximum	98.000



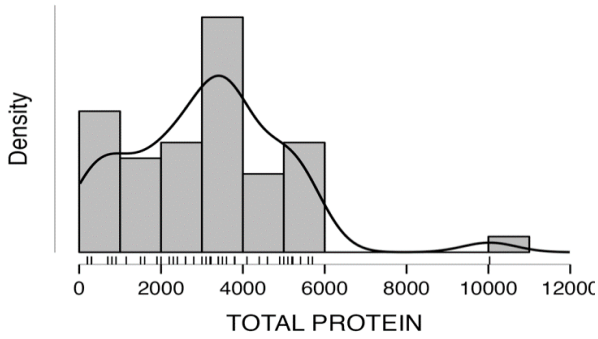
3. Lymphocytes

	LYMPHO
Valid	50
Mean	62.140
Std. Deviation	29.042
Coefficient of variation	0.467
Minimum	2.000
Maximum	95.000



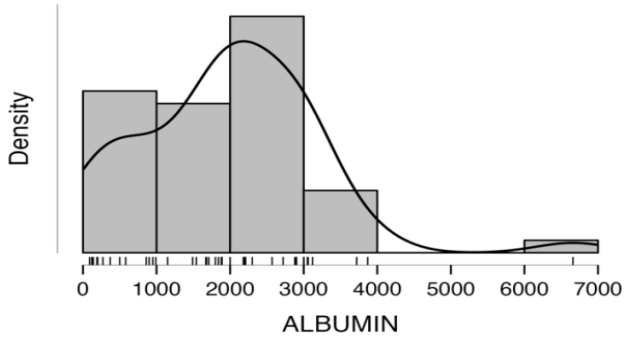
4. Total protein

	TOTAL PROTEIN
Valid	50
Mean	3110.600
Std. Deviation	1900.197
Coefficient of variation	0.611
Minimum	200.000
Maximum	10030.000



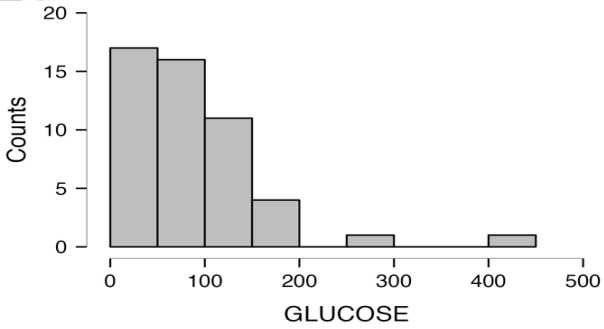
5. Albumin

	ALBUMIN
Valid	50
Mean	1978.400
Std. Deviation	1223.755
Coefficient of variation	0.619
Minimum	90.000
Maximum	6660.000



6. Glucose

	GLUCOSE
Valid	50
Mean	87.914
Std. Deviation	76.100
Minimum	10.000
Maximum	426.600



DISCUSSION

Physical Examination

Under physical examination the arthrocentesis fluid was observed to be of straw color suggestive of exudative character of the synovial fluid.

The aspirated arthrocentesis fluid was observed to be having low viscosity in comparison to the normal again suggestive of low-grade chronic synovitis associated with the arthropathy. Viscosity of a synovial fluid is decreased because of decreased production and polymerization of hyaluronic acid.

Bio-Chemistry Analysis

Glucose

Glucose is significantly decreased in inflammatory (e.g., immunologic disorders, lupus, scleroderma, ankylosis, crystal-induced gout and pseudogout, rheumatoid arthritis) and septic joint diseases. Average glucose level in arthrocentesis fluid is recorded around the 87.914mg/dL which is observed slightly on the lower side as all the samples were taken with the subjects not in the fasting state, in relation to the concept that the glucose concentration in synovial fluid should be similar to that of serum.

Protein-level

Total protein content was observed 3.110gm/L. Synovial fluid protein levels greater than 2.5 g/dl are abnormal, and those greater than 4.5g/dl indicate significant inflammation. The pre-albumin level around 1.978gm/dL which is suggestive of mild to moderate inflammatory condition. Inflammation leads to lower levels of albumin in the blood due to increased leakage of serum albumin and other plasma components into surrounding tissues and cells. This drop in albumin may not be offset by the body's increased production of it. Inflammatory conditions that demand an immune response, cell growth, and tissue healing benefit from higher albumin production. Albumin serves a protective and anti-oxidative role in the tissue spaces and can be broken down in cells to

provide essential amino acids for cell growth and tissue repair.

Microscopic Evaluation

Under the Microscopic evaluation total WBC count was observed around 2204.760 cells/µL with differential neutrophil count of 37.78% and lymphocyte count around 62.14% (e.g., cell count and differential count, crystal identification) which is suggestive of mild inflammatory change.

Clinical Significance

Analysis of joint fluid yields a definitive diagnostic support so as to plan for the rational treatment.

CONCLUSION

In synovial fluid analysis the mean WBC count of 2204.760 cells/ µL, the mean Nutrophils count of 37.78%, the mean Lymphocytes of 62.14%, total protein mean with the value of 3.110gm/L and albumin mean was observed to be 1.978gm/dL. These observations strongly indicate a scenario of chronic nonspecific knee effusion with low-grade inflammatory changes.

Overall observations of 50 cases recorded in synovial fluid analysis also revealed that this condition is associated with the laboratory findings suggestive of the scenario associated with mild to moderate inflammation.

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