Original Article

Comparative evaluation of efficacy of C-reactive protein versus total leucocyte count as marker for monitoring patients with orofacial space infection of odontogenic origin

ABSTRACT

Objective: To compare and evaluate the efficacy of C-Reactive Protein and total leucocyte count as markers for monitoring patients of odontogenic space infection.

Materials and Methods: Blood samples were taken preoperatively and post-operatively at day 1, day 2, day 3 and day 7 for measuring the levels of CRP and TLC. The trends of CRP and TLC were analysed against the Clinical Severity Scale (CSS). The study was carried out on patients of odontogenic space infection, and minimum of 50 patients were selected for this study. Comparative evaluation of C-reactive protein (CRP) versus total leucocyte count (TLC) was performed.

Results: Data were analysed using Statistical Package for Social Sciences (SPSS) version 21. Inferential statistics were performed using Spearman Correlation. The level of statistical significance was set at 0.05. The result of the study demonstrates that the C-reactive protein (CRP) was found to be more consistent indicator for monitoring the patients of odontogenic space infection than TLC, Differential Leucocyte Count (DLC) and erythrocyte sedimentation rate (ESR).

Conclusion: We conclude that CRP should be incorporated as monitoring tool, and it serves as a better indicator than TLC for managing patients with orofacial space infections of odontogenic origin.

Keywords: CRP, odontogenic space infection, orofacial space infection, TLC

INTRODUCTION

Maxillofacial infection is one of the life threatening conditions, despite greatly improved health services available in present era, severe odontogenic infections still remains leading cause of morbidity and mortality. Lethal complications like upper airway obstruction, descending mediastinitis, thrombosis of jugular vein, venous septic emboli, rupture of carotid artery, adult respiratory distress syndrome, pericarditis, septic shock and disseminated intravascular coagulopathy may become inevitable.[1] Both C-reactive protein (CRP) and total leucocyte count (TLC) have been known to rise in an infectious process. Total leucocyte count represents the cellular arm of immunity whereas C-reactive protein is the humoral component. Rise in serum

Access this article online	
Website: www.njms.in	Quick Response Code
DOI: 10.4103/njms.njms_139_22	

Dhanashri Jadhav, Gaurav Singh[1], Madan Mishra[1], Abhinav Srivastava[1], Shubhamoy Mondal[1]

Consultant Oral and Maxillofacial Surgeon, Mumbai, Maharashtra, [1]Department of Oral and Maxillofacial Surgery, Sardar Patel Post Graduate Institute of Dental and Medical Sciences, Lucknow, Uttar Pradesh, India

Address for correspondence: Dr. Madan Mishra, Professor, Department of Oral and Maxillofacial Surgery, Sardar Patel Post Graduate Institute of Dental and Medical Sciences, Lucknow, Uttar Pradesh, India.
E-mail: mm.15mds@gmail.com

Received: 03 August 2022, **Revised:** 06 December 2022, **Accepted:** 12 December 2022, **Published:** 10 November 2023

How to cite this article: Jadhav D, Singh G, Mishra M, Srivastava A, Mondal S. Comparative evaluation of efficacy of C-reactive protein versus total leucocyte count as marker for monitoring patients with orofacial space infection of odontogenic origin. Natl J Maxillofac Surg 2023;14:406-12.

C-reactive protein concentration is seen up to 1000 fold within few hours of severe infections. Also it has a very short half-life of 5–7 hours as compared to a life span of 5–6 days for leucocytes. This short half-life makes it a more sensitive indicator of infection.[2]

C-reactive protein (CRP) is a pentameric acute phase reactant discovered in 1930 in pneumococcal pneumonia patients.[3] C-reactive protein (CRP) is present only in small amounts in normal healthy individuals and is involved in process of innate immune system with functions of complement activation, antigen clearance and mediation of phagocytosis by activation neutrophils. Traditionally, the protein has been used clinically for diagnosis and monitoring of autoimmune and infectious disorders.[3]

C-reactive protein is normally found at concentrations of less than 10 mg/L in the blood. During infectious or inflammatory disease states, C-reactive protein levels rise rapidly within the first 6 to 8 hours and peak at levels of up to 350-400 mg/L after 48 hours.[4] Its rapid rise and falls make it a much more sensitive predictor than Erythrocytic Sedimentation Rate (ESR) and white blood cells (WBC) count. C-reactive protein binds to phosphocholine expressed on the surface of damaged cells, as well as to polysaccharides and peptosaccharides present on bacteria, parasites and fungi. This binding activates the classical complement cascade of the immune system and modulates the activity of phagocytic cells, supporting the role of C-reactive protein in the opsonization of infectious agents and dead or dying cells. When the inflammation or tissue destruction is resolved, C-reactive protein levels fall, making it a useful marker for monitoring disease activity.[4-7]

Aim of the study was to compare and evaluate the efficacy of C-reactive protein and total leucocyte count as markers for monitoring patients of odontogenic space infection.

MATERIALS AND METHODS

The study was carried out on patients with odontogenic space infection attending the outpatient department of Oral and Maxillofacial Surgery after seeking permission from institutional ethical committee from the year 2017 to 2019 (IECnumber-251718/OMFS/IEC/05). A written-informed consent was obtained from each patient after explaining the nature and outcome of procedure and the possible consequences and complications. Patients were selected irrespective of caste, sex, religion or socio-economic status.

Inclusion and exclusion criteria

50 patients reporting with odontogenic space infection were included in this study. Pregnant and medically compromised patients were excluded from the study. Withdrawal criteria included patients not returning for check-up, follow up or documentation. Patients not following post-operative instruction.

A prospective clinical study was conducted in 50 patients of odontogenic space infections for 2 years from 2017 to 2019. All the patients underwent surgery using standard protocol along with removal of foci of infection under appropriate anaesthesia. Drainage was maintained with corrugated rubber drain. A Clinical Severity Scale (CSS) that could truly represent the severity of infection in the patient was used. The selection of loco-regional parameters was done and was assessed from the APACHE II (Acute physiology and chronic health evaluation) system.

According to APACHE II system, 9 clinical parameters were used to assess the patients (6 loco-regional and 3 systemic parameters). These six loco-regional (swelling, pain, pus, associated symptoms, associated signs and mouth opening) and three systemic (temperature, heart rate and respiratory rate) parameters are considered to be the indicators of clinical profile of a patient which were recorded preoperatively, on the 1st, 2nd, 3rd and 7th post-operative day, respectively.[8-10]

Measurements of the maximal inter-incisal distance, pain and facial width (swelling) were recorded preoperatively, on 1st, 2nd 3rd and 7th post-operative days, respectively. The maximal inter-incisal distance was measured, using a stainless steel metal scale, from the mesial angle of the incisal edge of the upper right central incisor to a corresponding point in the lower right central incisor. This was measured 3 times, and the mean was calculated. The facial width (swelling) was recorded using a modification of the tape measure method. The linear distances from the angle of the mandible to the tragus, lateral canthus, alae to nose angle, commissure of the lips and soft tissue pogonium were measured. Each linear measurement was repeated twice, and the mean was calculated.[11-14] Pain was evaluated using a 10-cm Visual Analogue Scale (VAS). Patients were given the VAS scoring sheet and instructed to mark the point that corresponded to their present pain level. This was also repeated twice.[15]

For each clinical indicator, a scoring between 0 and 4 was done in proportion to the severity of derangement. For pus, associated signs and symptoms a weighted binary scoring system was used, i.e., score 0 represented absence and score 4 represented the presence of the sign/symptom.

For temperature, the scoring was done as 0, 1, 3 and 4 considering the irrelevance of the score 2. Similarly, for heart rate scoring was done as 0, 2, 3 and 4 considering the irrelevance of score 1. For pain, Visual Analogue Scale (VAS) was used to calculate the pain score [Figure 1].[8]

Further based on the cumulative scores, grades were assigned. It was decided that a score of 0 indicated a NORMAL clinical profile, a score between 1 and 8 MILD clinical impact of infection, a score between 9 and 16 MODERATE and above 16 STRONG indicator of clinical impact of infection.[8]

Parameters	Criteria	Score
Loco-regional parameters[a]		
Swelling	Baseline score (at admission)	4
	<25 % reduction from baseline	3
	25–50 % reduction	2
	50–75 % reduction	1
	>75 % complete resolution	0
Pain	No pain	0
	Mild pain	1
	Moderate pain	2
	Severe pain	4
Pus	Absent	0
	Present	4
Associated symptoms[b]	Absent	0
	Present	4
Associated signs[c]	Absent	0
	Present	4
Mouth opening	<9 mm	4
	9–17 mm	3
	18–26 mm	2
	27–35 mm	1
	>35 mm	0
Systemic parameters[d]		
Temperature	36–38.4 °C	0
	38.5–38.9/34–35.9 °C	1
	30–31.9/39–40.9 °C	3
	≤29.9/≥41 °C	4
Heart rate	70–109	0
	55–69/110–139	2
	40–54/140–179	3
	<40/≥180	4
	12–24	0
Respiratory rate	10–11/25–34	1
	6–9	2
	35–49	3
	<5/≥50	4

Grades of Infection as per CSS Score: >16 = severe; 9–16 = moderate; 1–8 = mild; 0 = normal

[a] Loco regional parameters

[b] Associated symptoms—Dyspnoea, Dysphagia, Dysphonia

[c] Associated signs—Uvula deviation, obliteration of nasolabial fold/vestibule, Ocular signs

[d] Systemic criteria (modifed from: APACHE II)

Figure 1: Clinical severity scale

Investigations and management

Patients underwent blood investigations like CRP, TLC, DLC and ESR preoperatively, on 1st, 2nd, 3rd and 7th post-operative days, respectively. All the blood samples were withdrawn in fasting state and sent to same laboratory. Post-operatively intravenous antibiotics I.V Amoxicillin 1000 mg/clavulanate 200 mg 12 hourly together with I.V. Metronidazole 500 mg 8 hourly and anti-inflammatory (Diclofenac sodium + Paracetomol TDS) drugs were continued for 5 days post-operatively. Patients were advised to maintain oral hygiene by rinsing with 0.2% Chlorhexidine gluconate mouthwash and warm saline gargle 24 hrs after surgery. Patients were advised strictly liquid diet.

Statistical analysis

Data was entered into Microsoft Excel spreadsheet and then checked for any missing entries. It was analysed using Statistical Package for Social Sciences (SPSS) version 21. Continuous variables were summarized as mean and standard deviation. Categorical variables were summarized as absolute and relative frequencies. Inferential statistics were performed using **Spearman Correlation Coefficient**. The level of statistical significance was set at 0.05.

RESULTS

The Clinical Severity Scale (CSS) in 50 patients of orofacial space infection was evaluated against the inflammatory markers TLC, DLC, CRP and ESR. The patients aged between 18 and 60 years including 30 female (60%) and 20 male (40%).

CRP (in mg/dl) was found to be increased than the baseline pre-operatively (50.50 ± 13.55) at the 1st day (62.62 ± 15.92) and 2nd day (72.12 ± 17.63) post-operatively and gradually decreased at 3rd day (46.30 ± 17.82) and 7th day (22.38 ± 15.80) post-operatively [Table 1].

Total leucocyte count (TLC) was found to be gradually decreasing than the baseline pre-operatively (10.73 ± 2.02)

Table 1: Comparison of C-reactive protein (CRP) levels at different postoperative periods (in milligram/litre)

	CRP levels				
	n	Minimum	Maximum	Mean	Std. Deviation
Pre operative	50	31	80	50.50	13.553
At 1st day	50	42.0	102.0	62.620	15.9219
At 2nd day	50	29	120	72.12	17.632
At 3rd day	50	17	98	46.30	17.827
At 7th day	50	6.0	70.0	22.386	15.8022

at the 1st day (9.55 ± 2.06), 2nd day (8.92 ± 2.13), 3rd day (8.33 ± 2.25) and 7th day (7.62 ± 1.89) post-operatively [Graph 1] and the Differential Leucocyte Count (DLC) was found to be decreasing than the baseline (pre-operatively) at the 1st day, 2nd day, 3rd day and 7th day post-operatively [Table 2].

ESR (in mm/hr) was found to be decreasing than the baseline pre-operatively (48.84 ± 14.37), at the 1st day (43.96 ± 14.31), 2nd day (39.28 ± 14.09), 3rd day (34.86 ± 14.33) and 7th day (26.06 ± 12.84) post-operatively [Graph 2].

The CSS at different time interval clearly show a shift from severe to mild which is closely correlated with decreasing CRP values specially at 3rd and 7th postoperative day [Tables 3 and 4].

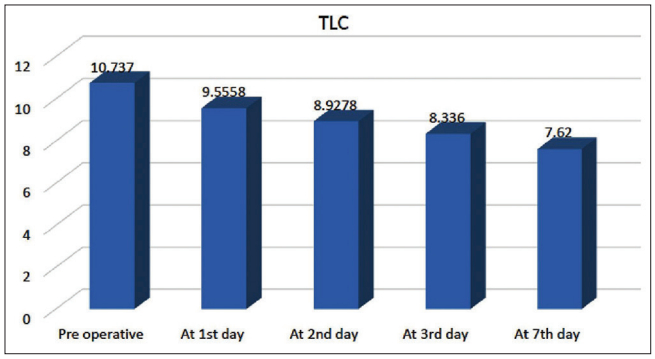
DISCUSSION

There are various inflammatory markers to detect the clinical severity of infection in patients with orofacial space infection. Visual Analogue Scale (VAS) is a simple method for assessing pain in patients with orofacial space infection. It provides continuous scale for magnitude estimation and consists of straight line; the ends of the straight line are defined to determine extreme limits of pain experience.[10] Many authors argued over Mc Gill pain Questionnaire (MPQ) for pain measurement. However, MPQ being verbal method requires translation and renewed scaling to be useful outside English speaking countries. Therefore, despite of having some disadvantages, VAS is most frequently used method for measurement of clinical pain. On the scale of 100 mm, 0-4 mm indicated no pain; 5-44 mm mild pain; 45-74 mm moderate pain; and 75-100 mm severe pain.[10]

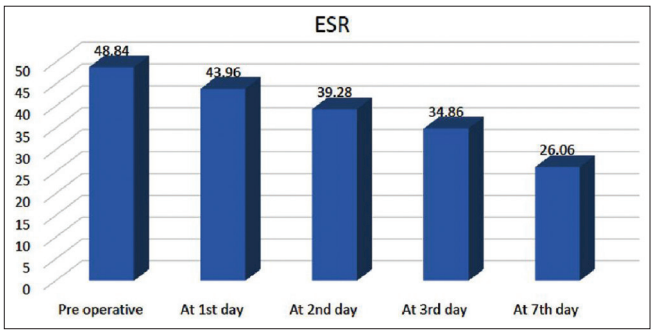
In this study, it was found that the pain gradually decreased from the baseline (preoperative day) at the 1st day, 2nd day, 3rd day and 7th day post-operatively and on the 7th day pain was minimum. The clinical parameters were assessed using Clinical Severity Scale (CSS). The scale included nine clinical indicators. In that six, loco-regional parameters were swelling, pain, pus, associated symptoms, associated signs and mouth opening, and three systemic parameters were temperature, heart rate and respiratory rate. For each clinical indicator, a scoring between 0 and 4 was done in proportion to the severity of derangement.[8]

For pus, associated signs and symptoms, a binary scoring system was used; score 0 represented absence and score 4 represented presence of sign/symptom. Scoring was done as 0, 1, 3 and 4 for temperature; 0, 2, 3 and 4 for heart rate and as 1, 2, 3 and 4 for respiratory rate. The systemic criteria were modified from APACHE II (Acute Physiology, Age, Chronic Health Evaluation II) system which is a classification for severity of disease.[8] Swelling in relation to temporal region was recorded by measuring the head circumference at the glabella region with the help of measuring tape. The facial swelling was recorded using a modification of the tape measure method described by Neupart *et al.*,[16] as modified by Filho *et al.*[17]

In this study, at 2nd post-operative day, head circumference swelling was found to be higher (55.618 ± 2.420) than



Graph 1: Comparison of Total Leucocyte count (TLC) at different Postoperative periods (in $\times 10^3$/millimeter^3)



Graph 2: Comparison of Erythrocytic Sedimentation rate (ESR) at different postoperative periods (in millimeter)

Table 2: Comparison of differential leukocyte count at different postoperative periods (in %)

Differential leukocyte Count (%)	*n*	Neutrophils (%)	Lymphocytes (%)	Eosinophils (%)	Monocytes (%)
Preoperative	50	83.63±4.39	11.72±3.67	2.20±1.57	3.00±1.1875
At 1st day	50	80.19±6.46	13.07±5.59	2.67±1.50	3.37±1.13
At 2nd day	50	78.65±6.17	14.11±5.80	2.54±1.29	3.28±1.29
At 3rd day	50	75.21±6.70	15.66±8.25	2.19±1.20	2.48±1.19
At 7th day	50	73.30±5.76	12.61±5.92	2.04±1.11	2.30±1.41

1st post-operative day (55.621 ± 2.412); and gradually decreased at 3rd post-operative day (55.581 ± 2.369) and 7th post-operative day (55.518 ± 2.265). The distances from the angle of mandible to the tragus, lateral canthus, alae of nose, commissure of the lips and soft tissue pogonion were measured. Each linear measurement was repeated twice and mean was calculated. The neck swelling was recorded by measuring neck circumference with help of measuring tape.[11-14] In this study, at 2nd post-operative day, facial swelling was found to be higher (12.47 ± 1.52) than 1st post-operative day (12.33 ± 1.52); and gradually decreased at 3rd post-operative day (12.06 ± 1.48) and 7th post-operative day (11.46 ± 1.47). At 2nd post-operative day, neck swelling was found to be higher (39.20 ± 5.01) than 1st post-operative day (38.56 ± 3.99); and gradually decreased at 3rd post-operative day (38.33 ± 3.63) and 7th post-operative day (37.44 ± 2.31).

Flynn *et al.* studied that most severe type of inter-incisal mouth opening (grade III) was associated with submassetric space infection. 76.5% of patients with submandibular space infection were affected with grade II trismus. The high incidence of trismus in these spaces was explained by the extent of swelling that interferes with the jaw movement with related pain. The highest duration of hospitalization was found in both submassetric and submandibular space, which were associated with grade II and grade III trismus. This highlights that degree of mouth opening can be considered as useful predictor for seriousness of the condition and attention should be directed towards correction of trismus throughout the treatment course.[18] In this study, inter-incisal mouth opening was found to be gradually increasing than its baseline level (preoperative day) at post-operative day 1, day 2, day 3 and day 7 of surgery. Increase in inter-incisal mouth opening on post-operative day 1, day 2, day 3 and day 7 were 26.32 ± 5.47, 28.46 ± 5.13, 30.68 ± 4.77 and 33.72 ± 3.68, respectively [Table 5].

Table 3: Comparison of clinical severity scale (CSS) at different postoperative periods (in %)

	Clinical severity scale							
	At 1st follow up		At 2nd follow up		At 3rd follow up		At 7th follow up	
	n	%	*n*	%	*n*	%	*n*	%
Normal	0	0%	0	0%	0	0%	0	0%
Mild	0	0%	0	0%	0	0%	35	70%
Moderate	28	56.0%	37	74.0%	50	100.0%	15	30%
Severe	22	44.0%	13	26.0%	0	0%	0	0%

A greater number of patients with purulent discharge were noticed on day 1 and 2. Gradual reduction of discharge was noted on subsequent post-operative visits. This finding is in concurrence with Adekeye and Adekeye (1982), who reported that after incision and drainage purulent exudates stopped within 2-3 days and resolution was completed within 5-12 days.[19] In this study, pus discharge was found to be highest on the pre-operative day (36.90 ± 10.35) and gradually decreased on the post-operative day 1 (12.42 ± 4.54), day 2 (3.34 ± 0.98), day 3 (1.42 ± 0.60) and day 7 (0.32 ± 0.54) [Table 6].

In the present study, we found that CRP had a high degree of correlation with severity of infection having *P* value 0.012, from preoperatively to day 3 and day 7. In a similar study, conducted by Pinilla *et al*.[20] they found statistically significant correlation between pre-albumin and CRP at 2nd and 5th day in infectious patients. CRP levels were found to be significantly high in most patients of space infection of odontogenic origin. Similar results were obtained by Ylijoki *et al*.[21]

In this study, it was observed that CRP was significant predictor for hospital stay, i.e., higher the CRP level, more was the hospital stay. C-reactive protein (CRP) was found to be increased than the baseline pre-operatively (50.50 ± 13.55) at the 1st day (62.62 ± 15.92) and 2nd day (72.12 ± 17.63) post-operatively and gradually decreased at 3rd day (46.30 ± 17.82) and 7th day (22.38 ± 15.80) post-operatively [Table 1]. In a study by Fatima Dogruel *et al*.,[22] neutrophil to lymphocyte (N/L) ratio was investigated in odontogenic infection patients, and it was observed that if N/L ratio is more than 5.19, the patients need a higher dose of antibiotics and stay more than one day in hospital for treatment of odontogenic space infection. Fang *et al*.[23] reported elevated N/L ratio in

Table 4: Correlation of CSS with CRP, TLC, differential leucocyte count (DLC) and ESR at different postoperative periods

	At 1st follow up		At 2nd follow up		At 3rd follow up		At 7th follow up	
	Rho	*P*	Rho	*P*	Rho	*P*	Rho	*P*
CRP	0.140	0.333, NS	0.195	0.174, NS	0.351	0.012, S	-0.059	0.683, NS
TLC	0.384	0.006, S	0.260	0.068, NS	0.175	0.224, NS	0.038	0.792, NS
Neutrophil count	0.095	0.513, NS	-0.218	0.128, NS	- 0.056	0.697, NS	0.043	0.771, NS
Lymphocyte count	-0.029	0.842, NS	0.274	0.054, NS	0.266	0.061, NS	-0.172	0.231, NS
Eosinophils count	-0.048	0.328, NS	0.168	0.244, NS	0.099	0.496, NS	0.071	0.626, NS
Monocyte count	-0.141	0.328, NS	0.104,	0.473, NS	0.068	0.637, NS	-0.015	0.916, NS
ESR	0.182	0.206, NS	0.267,	0.061, NS	0.184	0.200, NS	-0.045	0.754, NS

Table 5: Comparison of inter-incisal mouth opening at different postoperative periods (in millimeter)

	Interincisal distance (mm)				
	n	Minimum	Maximum	Mean	Std. Deviation
Pre operative	50	12.0	36.0	24.380	5.8863
At 1st day	50	15.0	36.0	26.320	5.4751
At 2nd day	50	18.0	36.0	28.460	5.1397
At 3rd day	50	20.0	39.0	30.680	4.7700
At 7th day	50	25.0	38.0	33.720	3.6814

Table 6: Comparison of pus discharge at different postoperative periods (in millilitre)

	PUS dischage (ml)				
	n	Minimum	Maximum	Mean	Std. Deviation
Pre operative	50	22.0	60.0	36.900	10.3554
At 1st day	50	6.0	25.0	12.420	4.5405
At 2nd day	50	2.0	6.0	3.340	0.9817
At 3rd day	50	1.0	3.0	1.420	0.6091
At 7th day	50	0.0	2.0	0.320	0.5417

patients of oral squamous cell carcinoma. Öztürk ZA *et al*.[24] reported higher N/L ratio in osteoporotic patients. The total leukocyte count (TLC) showed a consistent decline unlike CRP which increased at the 2nd post-op day and then decreased.

In this study, total leucocyte count (TLC) was found to be gradually decreasing than the baseline pre-operatively (10.73 ± 2.02) at the 1st day (9.55 ± 2.06), 2nd day (8.92 ± 2.13), 3rd day (8.33 ± 2.25) and 7th day (7.62 ± 1.89) post-operatively [Graph 1] and the Differential Leucocyte Count (DLC) was found to be decreasing than the baseline (pre-operatively) at the 1st day, 2nd day, 3rd day and 7th day post-operatively [Table 2]. This indicates that CRP is a more accurate marker than TLC in odontogenic space infection patients. In a study by Heimdahl and Nord, it was concluded that white blood cells (WBC) are less important for assessing the severity of odontogenic space infection.[25] When CRP and TLC were compared, it was observed that CRP is a better indicator of infectious process since CRP level rises faster as compared to WBC in odontogenic space infections.[25]

The non-specificity of the erythrocyte sedimentation rate means the test is more likely to be falsely positive (elevated in the absence of inflammation) than a C-reactive protein test. The erythrocyte sedimentation rate slow response to the acute phase reaction leads to false negatives early in an inflammatory process.[25] In a laboratory-based studies by Kushner *et al.,* examining consecutive patients with elevated C-reactive protein or erythrocyte sedimentation rate, C-reactive protein has been found to be a better marker of the acute phase reaction than the erythrocyte sedimentation rate. It is a more sensitive test and rapidly detects changes in the acute phase reaction.[26]

In a retrospective cohort study by Feldman *et al.*, discrepancies between C-reactive protein and erythrocyte sedimentation rate have been reported in 12.5% of patients.[27] Patients with raised C-reactive protein and a normal erythrocyte sedimentation rate usually have infection. These discrepancies may be due to timing, with the rise in C-reactive protein manifesting itself before the sedimentation rate elevates, or simply because the sedimentation rate does not change with minor inflammation.[28] In this study, Erythrocytic Sedimentation Rate (ESR) was found to be decreasing than the baseline pre-operatively (48.84 ± 14.37), at the 1st day (43.96 ± 14.31), 2nd day (39.28 ± 14.09), 3rd day (34.86 ± 14.33) and th7 day (26.06 ± 12.84) post-operatively [Graph 2].

In this study, the Clinical Severity Scale (CSS) and laboratory parameters were correlated and assessed and it was found that mean values of CRP, TLC and DLC showed incremental trend with increasing CSS grade. Overall evaluation was done between CSS and other biomarkers like TLC, DLC, ESR and CRP and it was found that there was positive correlation observed with CRP and TLC [Tables 3 and 4].

CONCLUSION

This study concluded that CRP is found to be more consistent indicator for monitoring the severity in patients with odontogenic space infection ($p = 0.012$). More consistent relation of the clinical findings of the patients was observed in correlation to CRP as compared to TLC.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Bagul R, Sanjay C, Sane V, Patil S. Comparative evaluation of C-reactive protein and WBC count in fascial space infections of odontogenic origin. J Maxillofac Oral Surg 2017;16:238-42.
2. Roman M, Shareef A, Victoria Y, Imad A. Severity score as a prognostic factor for management of infections of odontogenic origin, a study of 100 cases. Open J Stomat 2017;7:25-34.
3. Naik S, Balreddy, Sridhar, Prasad, Praveen. Efficacy of serum C-reactive protein levels as monitoring tools for patients with infections of odontogenic origin – A clinical and biochemical study. Int J Healthcare Biomed Res 2015;4:32-9.
4. Bachofen VK. A review on the biological properties of C-reactive protein. Immunobiology 1991;183:133–45.
5. Pepys MB. C-reactive protein fifty years on. Lancet 1981;1:653–7.
6. Palosuo T, Husman T, Koistinen J, Aho K. C-reactive protein in population samples. Acta Med Scand 1986;220:175–9.
7. Young B, Gleeson M, Cripps AW. C-reactive protein: A critical review. Pathology 1991;23:118-24.

8. Bali R, Sharma P, Ghangas P, Gupta N, Tiwari JD, Singh A, *et al*. To compare the efficacy of C-reactive protein and total leucocyte count as markers for monitoring the course of odontogenic space infections. J Maxillofac Oral Surg 2017;16:322-7.
9. Groth T, Peterson H, Hjelm M. Characterization of increased synthesis of acute phase proteins from plasma concentration measurements. Comput Prog Biomed 1978;8:295-310.
10. Carlsson AM. Assessment of chronic pain. I. Aspects of the reliability and validity of the visual analogue scale. Pain 1983;16:87-101.
11. Forest JC, Larivière F, Dolcé P, Masson M, Nadeau L. C-Reactive protein as biochemical indicator of bacterial infection in neonates. Clin Biochem 1986;19:192-4.
12. Volanakis J. Human C-reactive protein: Expression, structure, and function. Mol Immunol 2001;38:189-97.
13. Black S, Kushner I, Samols D. C-reactive protein. J Biol Chem 2004;279:48487-90.
14. Terry W, Mold C. C-Reactive protein an activator of innate immunity and a modulator of adaptive immunity. Immunol Res 2004;30:261-77.
15. Huang T, Tseng F, Yeh T, Hsu C, Chen Y. Factors affecting the bacteriology of deep neck infection: A retrospective study of 128 patients. Acta Oto-Laryngol 2006;126:396-401.
16. Neupart EA, Lee JW, Philput CB, Gordon JR. The evaluation of dexamethasone for reduction of postsurgical sequelae of third molar removal. J Oral Maxillofac Surg 1992;50:1177-82.
17. Filho JR, Silva EO, Carmago IB, Gouveia FM. The influence of cryotherapy on reduction of swelling, pain and trismus after third molar extraction: A preliminary study. J Am Dent Assoc 2005;136:774-8.
18. Flynn TR, Shanti MH, Levi AK, Adamo RA, Kraut NT. Severe odontogenic infections, part 1: Prospective report. J Oral Maxillofac Surg 2006;64:1093-103.
19. Adekeye E, Adekeye J. The pathogenesis and microbiology of idiopathic cervicofacial abscesses. Oral Surg 1982;82:100-6.
20. Pinilla JC, Hayes P, Laverty W, Arnold C, Laxdal V. The C reactive protein to prealbumin ratio correlates with the severity of multiple organ dysfunction. Surgery 1988;124:799-805.
21. Ylijoki S, Suuronen R, Jousimies-Somer H, Meurman JH, Lindqvist C. Difference between patients with or without the need for intensive care due to severe odontogenic infections. J Oral MaxillofacSurg 2001;59:867-72.
22. Dogruel F, Zeynep B, Dilek G, Gokman Z, Alper A. The Neutrophil-to-lymphocyte ratio as a marker of recovery status in patients with severe dental infection. Med Oral Pathol Oral Cir Bucal 2017;22:440-5.
23. Fang HY, Huang XY, Chien HT, Chang JT, Liao CT, Huang JJ, *et al*. Refining the role of preoperative C-reactive protein by neutrophil/lymphocyte ratio in oral cavity squamous cell carcinoma. Laryngoscope 2013;123:2690-9.
24. Öztürk ZA, Yesil Y, Kuyumcu ME, Bilici M, Öztürk N, Yeşil NK, *et al*. Inverse relationship between neutrophil lymphocyte ratio (NLR) and bone mineral density (BMD) in elderly people. Arch Gerontol Geriatr 2013;57:81-5.
25. Harrison M. Erythrocyte sedimentation rate and C-Reactive protein. Aust Presc 2015;38:93-4.
26. Sharma A, Giraddi G, GokkulaKrishnan S, Shahi A. Efficacy of serum CRP levels as monitoring tools for patients with fascial space infections of odontogenic origin: A clinicobiochemical study. Nat J Maxillofac Surg 2012;3:148-51.
27. Feldman M, Aziz B, Kang GN, Opondo MA, Belz RK, Sellers C. C-reactive protein and erythrocyte sedimentation rate discordance: frequency and causes in adults. Translation Res 2013;161:37-43.
28. Sproston N, Ashworth J. Role of C-reactive protein at sites of inflammation and infection. Otolaryngol Pol 2017;71:39-45.